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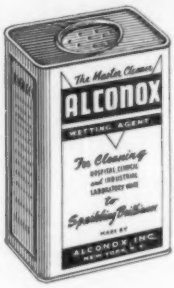

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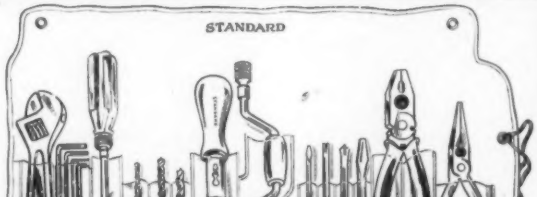

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Age of the Earth

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A NEW method for estimating the age of the earth consists of calculating a Pb^{207}/Pb^{206} age from the observed differences between the isotopic composition of recent lead isolated from the surface of the earth where appreciable concentrations of uranium exist and the isotopic composition of lead isolated from iron meteorites where insignificant concentrations of uranium are found (*1–3*).

The method is as follows. Let the isotopic composition of lead in the earth at the time it was formed be $Pb^{204}=1$, $Pb^{206}=x$, $Pb^{207}=y$, and $Pb^{208}=z$, where x, y, and z are the number of atoms of these isotopes for each atom of Pb^{204}; let the isotopic composition of lead in the earth today be $Pb^{204}=1$, $Pb^{206}=x'$, $Pb^{207}=y'$, $Pb^{208}=z'$. Then $\Delta Pb^{206}=(x'-x)$ is the amount of radiogenic Pb^{206} generated by U^{238} since the earth was formed, and similarly, $\Delta Pb^{207}=(y'-y)$ is the amount of radiogenic Pb^{207} generated by U^{235}. These amounts of radiogenic leads may be expressed in terms of the present U^{238}/U^{235} ratio, k, the disintegration constants of U^{235} and U^{238}, λ_1 and λ_2, and the period of decay, T, as

$$\frac{y'-y}{x'-x}=\frac{(e^{\lambda_1 T}-1)}{k(e^{\lambda_2 T}-1)}.$$

This expression is solved for T.

It is necessary to assume that when the earth was formed, it contained lead with an isotopic composition the same as that in iron meteorites, and that the ratio of lead to uranium has not changed, except for radioactive decay in the surface of the earth, since the surface was formed. On the basis of these assumptions, the values of x and y are measured in the lead from iron meteorites and the values of x' and y' are measured in a sample of the average lead in the earth's crust. The age of the earth calculated in this manner, about 4.5×10^9 yr, is considerably greater than the generally accepted estimate of 3.3×10^9 yr, and this paper is an attempt to view this new value in a proper perspective.

Relationship between meteorites and the earth. There are three main points of interest concerning the general relationship between meteorites and the earth. (i) Most meteoriticists believe that meteorites have heliocentric orbits; the basis for this belief is that the emission spectra of meteor trails indicate a close similarity of chemical composition between meteorites and meteors and that radar and photographic velocity data for meteors may be interpreted to mean that meteors have heliocentric orbits (*4*). (ii) There is apparently a 1-to-1 correlation, within experimental error, for the relative abundances of a large number of nonvolatile elements in meteorites and in the sun (*5, 6*); in addition, meteoritic material may be used to construct planet models that possess the physical and chemical properties of the earth (*6, 7*). (iii) No differences between the isotopic compositions of elements existing in meteorites and the earth have been found thus far, except for the few that can be explained by supposedly known and reasonable differences in conditions involving nuclear reactions or isotopic fractionations (*5*). Thus, there is some evidence for believing that meteorites are components of the solar system, that they as a whole do not represent uncommon and highly differentiated chemical systems relative to the earth, and that there is a uniformity of elemental isotopic compositions in both the earth and meteorites. In view of this, there are several possibilities concerning lead and uranium in meteorites that should not be ignored: namely, that the concentrations of lead and uranium in chondrites may be a rough measure of the concentrations of these elements in the earth as a whole, and that the lead in iron meteorites, which contain insignificant amounts of uranium, may represent the kind of lead that existed in the earth when it was formed.

Recently published measurements of the concentrations of lead and uranium in meteorites are listed in Table 1. Since these data were published another sample of lead, isolated from the sulfide phase of the Henbury, Australia, iron meteorite, has been analyzed in the mass spectrometer, and this analysis is included in Table 1. The isotopic compositions of the leads from both iron meteorites are the same, although one is a coarse octahedrite (and in gallium class I) and the other is a medium octahedrite (and in gallium class II). This would indicate that the isotopic composition of lead in iron meteorites is uniform. The isotopic composition of lead, however, is critically dependent upon relative concentrations, during the chemical his-

Table 1. Lead and uranium in meteorites (*5*).

Sample	U (ppm)	Pb (ppm)	Pb composition		
			206/204	207/204	208/204
Canyon Diablo metal phase		0.37*	9.7*	10.5*	29.3*
Average of iron meteorites	0.001 (*9*) (*10*)				
Canyon Diablo troilite	.009	18	9.41	10.27	29.16
Henbury troilite		5	9.50	10.30	29.26
Modoc total stone	.011	0.9			
Norton County total stone	.010				

* Corrected for about 20-percent terrestrial lead contamination introduced during chemical processing.

tories, of uranium, thorium, and lead, and the necessary exact knowledge of these chemical histories in meteorites is lacking at present. For example, the lead now found in iron meteorites may have been exposed to an environment containing higher concentrations of uranium for an unknown period of time before the meteorites were formed. It is not known whether the lead existing in the earth was exposed to a similar environment. There is no evidence, therefore, that compels us to assume that when the earth was formed it contained lead with the same isotopic composition as that in iron meteorites, although such an assumption is necessary for the age calculations.

For the present, the values in Table 1 can be used to estimate the relative abundances of lead and uranium in chondritic material as about 8×10^{-8} atom per 10^4 atoms of Si and 1×10^{-4} atom per 10^4 atoms of Si, respectively. A detailed study of some trace elements in a large number of iron meteorites (*11*) has shown that extensive, though perhaps systematic, variations in the concentrations of those trace elements occur. For this reason, the values given here might differ somewhat from those chosen as significant after a detailed study of these two elements in meteoritic material has been made. High concentrations of lead and uranium in minor phases such as troilite may produce an uncertainty of a factor of about 2 in the concentrations of these two elements in meteoritic material, since the amounts of these minor phases may vary widely in different portions of the same meteorite, and it is difficult to obtain representative samples. The values given here are probably significant to within a factor of about 5 of meteoritic concentrations, assuming that they do not represent extremes of possible variations. If the earth were made of a material with a chemical composition similar to chondritic meteorites (*6*) or of a material represented by a reasonable combination of iron and stone meteorites (*5*), then the foregoing figures would express the abundances of lead and uranium relative to silicon for the earth as a whole.

Primary radiogenic lead growth pattern in the earth. The isotopic compositions have been determined for a number of leads (*12*) isolated from macro lead minerals occurring in mineralized areas that have supposedly been dated either by macro uranium minerals or by post-Cambrian stratigraphy. If the isotopic compositions of these ore leads are arranged according to the times of mineralization of the veins in which they occur, then there is a rough but obvious regularity: the oldest ore leads are least radiogenic, and the younger and younger ore leads become progressively more and more radiogenic.

Upon this evidence, some investigators have assumed that most ore leads are derived at various times from a system of lead and uranium in which the mean Pb/U ratio has not changed except for radioactive decay since the elements were formed. These investigators feel that this primary radiogenic lead growth pattern in the earth has been determined with sufficient accuracy and is reliable enough to provide both a basis for estimating the times at which ore leads are formed (*3, 13*) and a basis for estimating the age of the elements (*14, 15*). In a statistical treatment of a number of lead ores formed during the last 2×10^9 yr, Collins, Russell, and Farquhar (*15*) have calculated that the rate of radiogenic growth in ore leads should result from a ratio of Pb/U in the earth which is 6.4 by weight at present. They have also calculated the isotopic composition of the average ore lead at various times of formation. For purposes of illustration, the curves calculated by them are reproduced in Fig. 1.

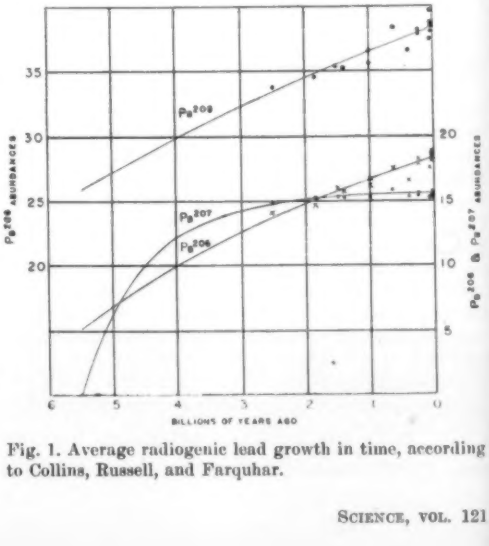

Fig. 1. Average radiogenic lead growth in time, according to Collins, Russell, and Farquhar.

If the primary growth trend is projected back in time to the isotopic composition of the lead we have found in iron meteorites, the time of approximate equality is found to be about 4.5×10^9 yr. This can be interpreted to mean that the calculated lead-uranium and lead-thorium ages for the earth agree with the lead-lead age for the earth, where in the first cases the calculations are based upon the rates of radiogenic growth in lead ores, and in the last case the calculation is based upon a recent sample of average crustal lead.

Although a general trend is apparent in the growth pattern of radiogenic lead in the earth, and we use the Pb/U ratio obtained by Collins, Russell, and Farquhar later in this paper, we do not at present share this same feeling of confidence in the reliability of this primary growth pattern. There is evidence that old and extensive chemical systems exist in the earth which possess widely different ratios of Pb/U, and the effects of the interactions of these systems upon the isotopic compositions of ore leads must still be evaluated. The extension of this fixed growth pattern back to the time of element formation cannot be justified at all and should be viewed with great reservation.

Effects of differentiation of crust from mantle. In simplified terms, the crust of the earth may be considered as a surface one-half covered by a basaltic layer about 10 km thick and the other half covered by a granitic layer about 10 km thick, together with a basaltic layer about 30 km thick underlying the granitic layer. Using commonly accepted values (*16*) for the concentrations of lead and uranium in granites and basalts and assuming that the earth is made of chondritic material, estimates for the fractions of total earth lead and uranium contained in these two layers are given in Table 2.

The figures in Table 2 suggest that an extreme differentiation of uranium relative to lead has occurred within the earth: nearly all of the uranium in the earth is concentrated near its surface and most of the lead is not. This differentiation would tend to make the Pb^{207}/Pb^{206} age calculated for the earth a minimum value.

The effect of such a differentiation process upon the isotopic compositions of leads existing near the earth's surface may be evaluated in the following way. Consider the Pb^{207}/Pb^{206} age of about 4.5×10^9 yr obtained from the difference between meteoritic and terrestrial leads as a rough measure of the period during which mantle differentiation has occurred. The observed radiogenic lead deficiencies in the earth's crust may be obtained by first calculating the relative amounts of radiogenic lead that should have been produced during this period using the present ratio of lead to uranium in the earth's crust, and then comparing these amounts with those obtained by subtracting the isotopic composition of meteorite lead from the isotopic composition of young crustal lead. Unfortunately the present ratio of lead to uranium in the earth's crust, as given by analyses of these two elements in various materials, varies widely and the uncertainty of the quality of the data and the character of the samples is so great that direct measurements cannot be used at the present time. Perhaps the least objectionable estimate for this ratio may be that of 6.4 obtained by Collins, Russell, and Farquhar, since their assumptions may be sufficiently correct for about the last 1×10^9 yr. From this ratio of lead to uranium, it is calculated that 9.9 and 5.6 atoms of radiogenic Pb^{206} and Pb^{207} per atom of Pb^{204} should have been formed in the earth's crust during the last 4.5×10^9 yr. The isotopic compositions of leads isolated from oceanic deposits (*17*), which are mentioned later in this paper, may constitute an experimental determination of the isotopic composition of the average lead in the earth's crust. The differences between the isotopic composition of this lead and meteoritic lead indicate that 9.5 and 5.4 atoms of radiogenic Pb^{206} and Pb^{207} per atom of Pb^{204} exist in the earth's crust today.

Table 2. Approximate distribution of lead and uranium in the earth.

Material	Pb (ppm)	Earth's total Pb (%)	U (ppm)	Earth's total U (%)
5 km of granite	10	1	4	50
20 km of basalt	5	3	0.8	40
Interior		96		10

For this fixed period of 4.5×10^9 yr, it is sufficient to calculate the deficiencies of radiogenic lead in the crust of the earth as a function of the rate of transfer of uranium from the interior to the crust by assuming that the rate of this transfer is proportional to the uranium concentration in the interior and that the transfer of lead is negligible. From such a point of view, deficiencies of less than 5 percent of radiogenic Pb^{207} in the crust require that the transfer of uranium be one-half completed in less than 50 million years. Thus, apparently negligible deficiencies of radiogenic Pb^{207} and Pb^{206} exist in the crust, and it would appear that either mantle differentiation effects are minimal, perhaps as a result of large initial transfer rates, or the application of meteoritic concentration data is in error, the amounts of uranium assigned to the whole earth being too low.

Effects of differentiation within the crust. It is important that we recognize the possibility of systematic variations in the ratios of lead to uranium in different crustal materials and the consequent effects of intracrustal differentiation upon the isotopic composition of lead within the crust. In the preceding paragraphs it has been shown that the ratio of lead to uranium in the earth's mantle may be very high (in the range of 50 to 100) and that the isotopic composition of lead in such ultra deep-seated materials should be grossly nonradiogenic. In the lower parts of the crust or in basalts, a few concentration measurements show that the ratio of lead to uranium is about 6. In the

Table 3. Lead and uranium in earth materials.

Sample		Pb (ppm)	U (ppm)	Th (ppm)	Pb/U	206/204	207/204	208/204	References
Plateau basalt (Quaternary)	Today	0.55	0.65	2.02	10.1	18.13	15.45	38.08	
Basalts and gabbros		5	0.8		6				(*19*)
Canadian Shield granite	Today	9.3	2.74	41.9	3.4	20.25	15.65	48.73	(*18*)
	1.06×10^9 yr ago					16.81	15.28	36.02	(*18*)
Granites		10	4		2.5				(*20*)
Calculated average Pb	Today				6.4	18.5	15.6	38.4	(*15*)
Ore	1.06×10^9 yr ago					16.7	15.5	36.3	(*15*)
Red clay (Quaternary)	Today	35.2				18.95	15.76	38.92	(*17*)
Manganese nodule (Quaternary)	Today	3,450				18.91	15.69	38.68	(*17*)

upper part of the crust, or in granites, there are some measurements which show that the ratio of lead to uranium is about 3.

We have determined the concentrations of uranium, thorium, and lead in a sample of Quaternary flood basalt from the Snake River Plains of Southern Idaho. The concentrations of these three elements have also been determined in a pre-Cambrian alaskite granite from the Canadian shield in Ontario (*18*). These measurements constitute the only precise determinations that have been made of the Pb/U ratios in basalts and granites and the only determinations that have been made of the isotopic compositions of leads in such materials. All these data are summarized in Table 3.

The basalt was obtained from R. S. Cannon of the U.S. Geological Survey, Washington, D.C., who, because of his interest and knowledge of these problems, instigated its collection. The sample was collected by G. J. Neuerburg of the U.S. Geological Survey, Pasadena, California, with special concern regarding contamination and alteration. Neuerberg's report is as follows:

> This sample is a gray micro- and macrovesicular basalt from one of the several pressure-ridged flows that occupy the surface of the Snake River Plain. Judging from descriptions given by Stearns *et al.* (1938), it is one of the latest Pleistocene flows that preceded the extrusion of the black, glassier Recent lavas of which the Craters of the Moon is a prime example. The sample comes from a block deep within the textural profile of the flow that was excavated in construction of the Gooding-Shoshone canal, 1.8 mi north of Shoshone on U.S. Highway 93, Lincoln County, Idaho. The sample was collected from the northwest corner of the intersection of the highway and the canal.
>
> The texture is ophitic and the grain size averages 0.30 mm. Sparse microphenocrysts of olivine are set in a felted matrix of plagioclase (labradorite-andesine) and roundish grains of olivine with space-filling brownish augite and ilmenite or titaniferous magnetite; apatite is abundant. Zircon may be present? In a very few places, augite appears to be slightly altered to a dark brown clayey material; otherwise this sample is exceptionally fresh.

His estimate of the mineral composition, together with the chemical composition determined by W. J. Blake of the California Institute of Technology, is given in Table 4.

As Table 3 shows, the lead to uranium ratio of 10 measured in this basalt agrees well with the more qualitative measurements in other basalts and is distinctly greater than the Pb/U ratio observed in granites. If this basalt is considered to be a representative sample of a closed chemical system that has existed during the last 4.5×10^9 yr, then the amount of lead generated during this period by the decay of the uranium and thorium in the basalt may be calculated and compared with the observed amount of radiogenic lead in the basalt that is found by subtracting the nonradiogenic lead originally present. The isotopic composition of this original nonradiogenic lead may be assumed equal to that in iron meteorites. It is found that radiogenic Pb^{206} is 40 percent in excess and radiogenic Pb^{208} is 80 percent in excess in the basalt. It is quite clear from this gross radiogenic imbalance that the basalt may be chemically nonrepresentative of its source material or the rates of reaction and mixing of the basaltic system with other systems, in which the Pb/U ratios are lower, are rapid in terms of billions of years. The isotopic composition of the lead in the basalt, which was formed recently, is nearly identical with the calculated isotopic composition of an average ore lead formed today.

Listed in Table 3 is the ratio of Pb/U found in the granite by direct measurement. This value of 3 agrees with values found indirectly by measurements in other granites and is clearly much lower than the Pb/U ratio in basalts. If this granite is considered to be a representative sample of a closed chemical system that has existed during the last 4.5×10^9 yr and if a radiogenic balance is calculated in the same manner as for the basalt, it is found that radiogenic Pb^{206} is 50-percent deficient and radiogenic Pb^{208} is 80-percent deficient. Again it is clear that the granite may be chemically nonrepresentative of its source material or the granitic chemical system has reacted and mixed at rates that are rapid in terms of billions of years with other systems in which the Pb/U ratios are higher. The isotopic composition of the lead in this granite at the time granite was formed 1×10^9 yr ago was nearly identical with the calculated isotopic composition of an average ore lead formed at this same time.

Table 4. Mineral and chemical composition of the Shoshone basalt.

Mineral	Volume abundance (%)	Element	Weight abundance (%)	Element	Weight abundance (%)
Plagioclase (An_{62-42})	45	SiO_2	46.68	NaO	2.86
Olivine	10	TiO_2	2.95	K_2O	0.89
Augite	40	Al_2O_3	14.53	P_2O_5	1.20
Ore	4	Fe_2O_3	0.75	MnO	0.19
Apatite	1	FeO	12.78	H_2O^-	.01
		MgO	7.66	H_2O^+	.13
		CaO	9.76	Total	100.39

Table 3 shows the isotopic compositions of two leads isolated from two different Quaternary deposits occurring in the deep areas of the Pacific Ocean. The accumulation of lead in these samples during a period of 10^4 to 10^5 years might be considered to occur in such a way that the lead would be representative of an extremely large mass of material consisting of sedimentary rocks, granitic rocks, and basaltic rocks exposed to the weathering cycle. The isotopic compositions of these two leads are identical, although they are from deposits formed by supposedly different mechanisms (*21*) at widely different locations, and they are similar to the calculated isotopic composition of an average ore lead formed today. These oceanic lead samples may represent the average lead presently existing in the earth's crust.

It is remarkable that the isotopic compositions of the leads originally contained in the granite, the basalt, and the sedimentary deposits should be determined by approximately the same pattern of radiogenic lead growth, that this growth pattern should be very similar to the one calculated for an average ore lead, and that it should be independent of large variations of the Pb/U ratios in these kinds of materials that have a widespread occurrence. Thus, despite evidence of extensive and old chemical systems with very different Pb/U ratios existing in states that would strongly inhibit equilibration, there are definite indications that mixing may exert a first-order effect upon the isotopic compositions of leads in the earth's crust. These data, which indicate that there is extensive mixing and that the radiogenic imbalances of the basalt and the granite tend to cancel out, may eventually prove to be typical for most basalts and granites. This would be strong evidence for a differentiation relationship between acidic and basic rocks and create a difficult problem for those granitizationists who would minimize the role of basalts in the origin of granite.

It might be expected that different patterns of transient radiogenic lead growth would be measured as second-order effects superimposed upon the primary radiogenic lead pattern in old rock systems in the crust containing various Pb/U ratios. The nature of these effects would be determined by the influence of rock-forming processes in various phases of the overall geochemical cycles of lead and uranium in the earth's crust. The differences among the isotopic compositions of leads in various earth materials eventually may be instrumental in showing that certain postulated geologic processes are significant, while others are not. The present interpretations of lead data may be materially substantiated or drastically revised in the near future and are regarded as highly speculative now.

Age of the crust from lead ores. Holmes (*22*), Houtermans (*23*), and Bullard and Stanley (*24*) have used the lead ore data obtained by Nier (*25*) with certain assumptions to calculate an age for the earth's crust and the isotopic composition of primordial terrestrial lead. Collins, Russell, and Farquhar (*15*) have extended the set of galena data, repeated the calculations, and obtained values that agree with those calculated earlier. This method of calculating the age of the earth's crust has been widely discussed, a concise example being the paper by Alpher and Herman (*14*).

Nier pointed out in his original communications that the isotopic compositions of galenas varied with age in a manner that was consistent with the theory that the ores were derived from a system that possessed Pb/U and Pb/Th ratios similar to those found in the earth's crust. Following this, Holmes set forth the assumptions that have been used for all the calculations of the age of the earth's crust based on ore lead data. These assumptions are (i) lead had a uniform isotopic composition throughout the earth up to the time the crust was formed; (ii) when the crust was formed, the Pb/U and Pb/Th ratios in different areas varied slightly, were frozen, and did not subsequently vary except for radioactive decay; (iii) each ore lead has been derived from one such area and has not been mixed with lead from any other source; (iv) the time of formation of a galena can be determined either by stratigraphic correlation or by use of uranium minerals, and this is the time the ore was separated from the parent material in which the lead evolved.

If these assumptions are valid, one can express the isotopic composition of the lead in an ore of age t_m by the equations:

$$x_m = a_o - uV_m\,(e^{\lambda t_o} - e^{\lambda t_m}),$$

$$y_m = b_o - V_m\,(e^{\lambda' t_o} - e^{\lambda' t_m}),$$

$$z_m = c_o - W_m\,(e^{\lambda'' t_o} - e^{\lambda'' t_m}),$$

where x_m, y_m and z_m are the abundances of Pb^{206}, Pb^{207}, and Pb^{208} relative to Pb^{204} in the ore; a_o, b_o,

and c_o are the abundances of Pb^{206}, Pb^{207}, and Pb^{208} at t_o, the time the crust was formed; λ, λ', λ'' are the decay constants for U^{238}, U^{235}, and Th^{232}, respectively; V_m is the present-day ratio of U^{235} to Pb^{204} in the parent material from which the ore was derived; W_m is the ratio of Th^{232} to Pb^{204} in the same material; α is the present ratio of U^{238} to U^{235}. To solve for the age of the earth by the method of least squares, values of the parameters are sought which best fit the ore lead data, subject to the assumptions on which the calculation is made. The solutions obtained by the various authors are given in Table 5.

Table 5. Ore lead solutions for the earth's crust.

Author	t_o (10^9 yr)	a_o	b_o
Holmes (1947)	3.35	10.95	13.51
Houtermans (1947)	2.9	11.52	14.03
Bullard and Stanley (1949)	3.29	11.86	13.86
Collins, Russell, and Farquhar (1953)	3.5	11.83	13.55

Collins, Russell, and Farquhar used 17 galenas from as many different localities, averaging results when replicate determinations existed for the same deposit (erroneously, perhaps, in the case of their ore No. 6). Of the 17 ores used, five are taken as 25 million years old and a total of nine as less than 500 million years old. This weights the data heavily toward the more modern leads with greatly increased chances for the galenas concerned to have passed through successive environments with differing Pb/U ratios or to have been mixed with leads from other sources, violating the assumptions of the calculation. In addition to the difficulty of assessing the time of formation of the galenas, it is of course possible that this age does not represent the time elapsed since the lead was separated from the parent material that produced it.

Some ore leads have been clearly recognized as "anomalous" and have been excluded from the calculations, since no or aberrant solutions would result if they were not. Examples are the leads from Joplin, Missouri, the Worthington and Garson mines at Sudbury, Ontario, and the Colorado Plateaus (*12*). These leads are excessively contaminated by radiogenic lead or result from a marked increase in V_m at some time in the environment in which they evolved. Although "anomalous" leads can be recognized in extreme cases, there are no sensitive means for detecting "slightly anomalous" leads.

Of the ores used by Collins, Russell, and Farquhar, Nos. 2, 5, and 6 can satisfy the parameters and assumptions within quoted errors with assigned ages of 500 million years as well as 50 million years. Their ore No. 9 will satisfy the parameters with any assigned age between 200 and 900 million years.

Other ores used by them do not, individually, satisfy the parameters and assumptions within the quoted errors, unless the assigned ages are significantly altered. "Slightly anomalous" leads may have been included in the age calculations where their effect on the calculated value of t_o is difficult to assess but might lead to serious error. The exclusion of these "anomalous" leads, when they are so recognized, has not as yet been justified on acceptable theoretical grounds.

The most important and significant point is that the ore lead age calculation depends upon the *scatter* of the individual isotopic compositions about the curves representing the average radiogenic lead growth in time (Fig. 1). If all ore leads fell exactly upon the lines of average growth, no solution for the age of the crust would be possible by this method. Since the calculation is based on these second-order effects, small errors in the underlying assumptions may be capable of introducing large errors into the results. In view of the evidence for extensive mixing, it would seem contrary to the facts to postulate differing frozen Pb/U ratios that have existed for billions of years. The requirements of the assumptions in the ore lead method are so extreme it is unlikely that it should give a correct age.

We have, then, two methods for estimating the age of the earth: the ore method, which gives an age of 3.5×10^9 yr, and the meteorite method, which gives an age of 4.5×10^9 yr. The two methods may measure different "ages" in that the meteorite method measures the time elapsed since uranium was concentrated with respect to lead in the surface of the earth, while the ore method measures the time elapsed since local variations of the Pb/U ratio were established and frozen in the crust. Holmes has indicated a preference for this point of view (*26*). Houtermans has apparently abandoned the significance of the calculations of the [age of the] earth's crust using lead ores (*3*).

Conclusions. The ore lead method for estimating an age uses terrestrial materials but gives rise to serious uncertainty in the determination of the age of the crust. The meteorite method uses a primordial lead of accurately known isotopic composition and gives an accurately determined age but makes use of extraterrestrial materials whose relationship to the earth is uncertain.

There is no evidence that compels us to assume that when the earth was formed it contained lead with the same isotopic composition as that in iron meteorites. The choice of a suitable sample of recent terrestrial lead that may be compared with meteoritic lead is governed mainly by two requirements: namely, the sample should be derived from a closed chemical system of uranium and lead that has existed since the earth was formed, and the sample should be representative of all the lead in this system. Only a limited number of terrestrial lead samples have been isotopically analyzed. All these leads originate from masses of material that comprise only small fractions of the total mass of the earth. Knowledge of the character of these different mass fractions or chemical systems, the concentrations of uranium and lead in them, and the effects of their interactions with one another at various times upon the isotopic composition of lead in

them, is very meager. None of the concepts for the geneses of these leads have sufficient foundation in fact to fulfill justifiably the afore-mentioned requirement.

Nearly all analyzed terrestrial lead samples (except those from uranium minerals) that have been isolated from their uranium environments since Tertiary times (*12*) have isotopic compositions that fall within the range $Pb^{206}/Pb^{204} = 18.07$ and $Pb^{207}/Pb^{204} = 15.40$ to $Pb^{206}/Pb^{204} = 18.95$ and $Pb^{207}/Pb^{204} = 15.76$. When any of these leads are compared with the isotopic composition of lead from an iron meteorite, $Pb^{206}/Pb^{204} = 9.41$ and $Pb^{207}/Pb^{204} = 10.27$, a Pb^{207}/Pb^{206} age of approximately 4.5×10^9 yr is obtained. It should be recognized that an approximate age value is sufficient and should be viewed with considerable skepticism until the basic assumptions that are involved in the method of calculation are verified.

References and Notes

1. We discussed the essentials of this paper at a Conference on *Application of Nuclear Processes to Geological Problems* sponsored by the NSF and NRC, at Geneva, Wis., Sept. 1953. We gratefully acknowledge the cooperation and assistance by our colleagues, especially R. S. Cannon and G. J. Neuerburg of the U.S. Geological Survey and W. J. Blake of the California Institute of Technology. The portion of the work undertaken at the California Institute of Technology was supported by the U.S. Atomic Energy Commission, contract AT(11-1)-208.
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Effects of Atomic Explosions on Weather

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EVERY year since the explosion of the first atomic bomb, both the U.S. Weather Bureau and the Atomic Energy Commission have received many letters suggesting that atomic bombs should be used to dissipate hurricanes and tornadoes or otherwise improve undesirable weather. Since the atomic weapons testing program was enlarged in 1951, both agencies have also received complaints from many parts of the world blaming unpleasant weather on the atomic explosions.

Although a casual examination of much of the recent climatic data might appear to indicate that some of the recent anomalous weather has been associated with atomic explosions, a more careful examination of the data does not support the hypothesis that atomic explosions have changed the weather.

When the best available observational evidence and the most plausible theories are considered together, there appears to be no reason for believing that any past atomic explosion at the Nevada Proving Ground has had any significant effect on the weather more than a few miles from the test site.

Historical background. Although witnesses to atomic explosions have sought to find ways in which the awesome events may have altered the weather, few cases have been found in which even local effects occurred. The heat from the fires set by the atomic bomb at Hiroshima produced numerous showers in the moist air overlying the city, and the base surge of the underwater Bikini shot also led to the formation of showers that lasted for 20 to 30 min (*1*, *2*).

Most of the clouds from explosions in Nevada have been tracked for several hours by aircraft, but none of the pilots has reported any unusual weather developments during these operations. For greater distances, the atomic cloud has been followed across the United States by means of meteorologic trajectories (*3*), and even though there has been no attempt to make a detailed study of the weather in association with the atomic clouds and areas of radioactive fall-

out, it is believed that any marked relationship would have been detected.

These findings suggest that if the Nevada atomic tests had any effects on the weather, they were either very slight or very obscure. This article (*4*) describes a systematic study made possible in 1954 by the accumulation of additional data beyond that available to previous investigations.

Suggested relationships. To make sure that no reasonable hypothesis concerning the effects of atomic explosions on weather would be overlooked, suggestions were solicited from most of the organizations in the United States that employ meteorologists. Of the 80 or so replies received from these inquiries, about half indicated that the writers could see no possible connection between the atomic explosions and the ensuing weather. The others suggested that the atomic debris might serve as a cloud seeding agent; that the radioactive nature of the debris might produce changes in the electric parameters of the atmosphere, and that this, in turn, might produce some changes in the more directly observable weather elements; or that the dust resulting from an atomic explosion might interfere with the amount of solar radiation reaching the earth. None of those who replied believed that the energy of the atomic bombs exploded in Nevada could have any direct effect on the weather beyond the proving ground, and several volunteered arguments against this possibility.

We cannot, with our present knowledge of meteorology, dismiss the remote possibility that the atmosphere is so unstable that some small impulse such as that given by an atomic explosion could produce a weather change that might otherwise never take place. However there does not seem to be any reason why such modification would necessarily produce worse weather than might occur naturally. A consideration of the available theoretical and observational evidence indicates that the probability of any change is small.

Cloud seeding. Condensation does not begin in completely clean air until the relative humidity is at least 500 percent. Ordinary air, however, contains myriads of tiny dust particles—condensation nuclei—around which most natural cloud droplets are formed. Some of the nuclei can become active at relative humidities as low as 80 percent, and others such as ions require humidities greatly in excess of 100 percent. However, humidities in excess of 100 percent in the free air are rare. There are usually so many of these particles present and the available moisture is divided among so many droplets that none can grow large enough by the initial condensation process to fall as rain. But if water droplets and ice crystals are present in the same cloud, the ice particles will grow at the expense of the water droplets and become large enough to fall through the air. Additional growth will be realized by accretion of smaller droplets in the path of the falling drop. According to Houghton (*5*) the ice particle mechanism is necessary to the formation of most precipitation in middle and high latitudes. However the coagulation of cloud droplets is also important and in the tropics may be the most important process.

Cloud droplets do not freeze at the same temperature as a large volume of water. Liquid water droplets have been observed in the atmosphere at temperatures as low as about −40°F and at still lower temperatures in the laboratory. However, some of the nuclei have the property of causing the cloud droplets to freeze only a few degrees below the freezing temperature of bulk water. These particles, called ice nuclei (*6*), are not always present everywhere in the atmosphere and it is conceivable that the atomic explosions may supply them in regions with a natural

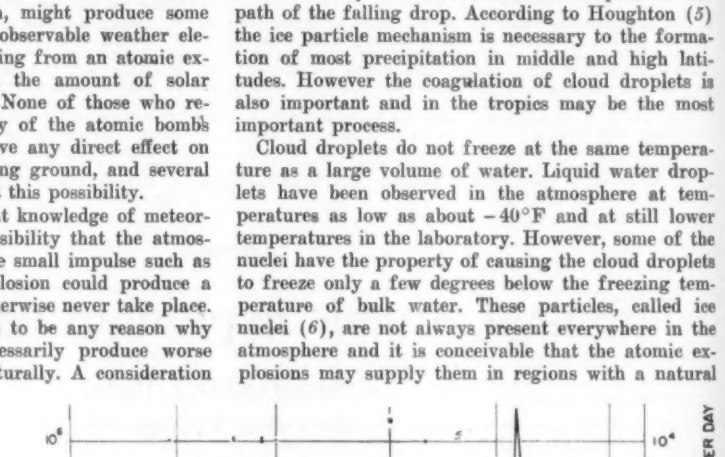

Fig. 1. Measurements of radioactive fallout (solid line) and ice nuclei count (small dots) made at Mount Washington, N.H., in 1952. Values for radioactive fallout of 10 disintegrations/ft² min are indicative of low values and not of accurate measurements.

deficiency. This possibility has been investigated by correlating the presence of ice nuclei and radioactive debris during a period of atomic explosions and by testing the nucleating properties of the material thrown into the air by the explosion.

Simultaneous measurements of the atomic debris and ice nuclei content of the air made at Mount Washington, N.H., in 1952 are shown in Fig. 1. The method of counting ice nuclei has been described by Schaefer (*7*); the method of measuring radioactive fallout has been described by Eisenbud and Harley (*8*). The continuous curve denotes the amount of radioactivity in dust deposited on the ground during a 24-hr period beginning at 12:30 P.M. EST on the date shown. The open circles are values interpolated from surrounding stations when reports from Mount Washington are missing. The smaller dots, usually eight per day, indicate the number of ice nuclei per cubic meter of air (*9*). If the debris from atomic bombs furnish good ice nuclei, the ice nuclei count should always be high when the radioactive fallout count is high. It is easy to see that this is not the case.

The only debris added to the air by an atomic explosion high above the ground is the material contained in the bomb itself, and only a small fraction, if any, of this material is thought to be effective as ice nuclei. In the case of low-altitude explosions a much greater amount of debris is thrown into the atmosphere. From the Nevada tests it has been found that more than 99 percent of the debris from a typical low-altitude atomic explosion consists of soil particles sucked up by the rising cloud without becoming radioactive or having their physical and chemical properties significantly altered by the explosion. Samples of this dust have been sent to two laboratories to be tested as ice nuclei. The Air Force Cambridge Research Center reported their findings as negative and Vincent Schaefer of the Munitalp Foundation emphasized the point by stating that the dust recovered from one rather muddy rain in Schenectady, N.Y., was 5000 times more effective than the dust from the Nevada Proving Ground.

The possibility that the radioactive nature of some of the debris might play a part in cloud seeding was also studied at the Air Force Cambridge Research Center, using laboratory sources of atomic radiations. None of the radioactive material tested was effective in promoting the formation of ice particles.

The amount of radioactivity deposited on the ground is much greater on days with precipitation than on days without precipitation when similar amounts of radioactive debris are aloft (*3*), and the precipitation is more radioactive when debris from atomic explosions is in the air than it is in the absence of such debris. However, it is well known that precipitation is effective in scavenging natural dust and smoke from the air. The available data indicate that most of the radioactive material in rainfall is collected by the scavenging process, and the presence of radioactive material in rain does not indicate that this material was instrumental in producing the rain.

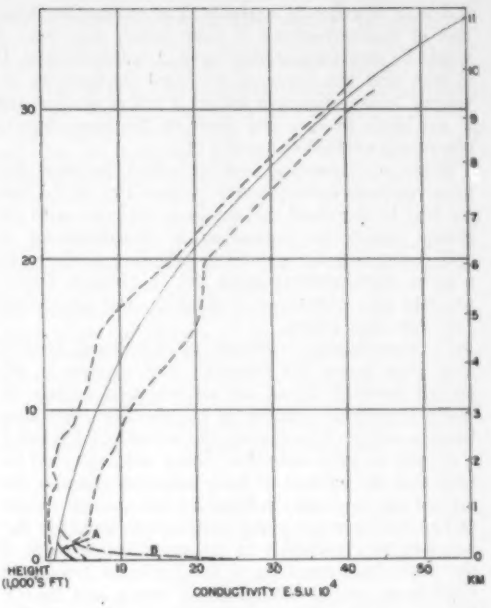

Fig. 2. Natural conductivity of the air and theoretical changes produced by fallout.

Electric effects. The radiations from the radioactive debris produced by an atomic explosion increase the ionization of the air. This should lead to an increase in the electric conductivity of the air and a decrease in the electric potential gradient of the atmosphere. A check of the records of atmospheric conductivity and potential gradient from the Tucson Geomagnetic Observatory of the Carnegie Institution of Washington for all periods of atomic tests through 1953 revealed only one case in which the electric parameters of the atmosphere were significantly altered as a result of radioactive fallout (*10*). Although very few observatories make continuous records of the electric conductivity of the atmosphere, observations of the increased radioactivity of the air, as well as theoretical considerations, indicate that the conductivity of the air near the ground may be significantly altered at many locations for four or five days after an atomic explosion.

The average natural conductivity of the free air as determined from more than 80 aircraft observations (*11*) is shown by the solid line in Fig. 2. The extreme values recorded are shown by the dashed lines. Theoretical considerations have been employed to compute the conductivity change expected in a region of moderately high fallout of radioactive material, such as may cover a few thousand square miles outside the proving ground following one of the larger bombs. This is shown by curve *A*. The conductivity to be expected near the largest observed fallout outside the

test area is given by curve *B*. The radioactive decay rate of fission products is quite rapid, and curve *B* would be transformed into curve *A* within 9 days. It is seen that this layer of increased conductivity resulting from radioactive fallout is rather shallow and is not likely to have any effect on the more directly observable weather elements (*12*).

However, theoretical considerations indicate that under extreme conditions the conductivity of the free air may be increased sufficiently to interfere with the charge separation mechanism in thunderstorms in such a way that the amount of lightning produced by a given cumulonimbus cloud will be reduced. Unfortunately no evidence for checking this hypothesis (*12*) has been found.

No observational evidence or theoretical reasons have been found for believing that changes in the electric conductivity of the air will lead to any directly observable changes in the weather other than the possibility of decreasing the amount of lightning.

Effects on solar radiation. Many meteorologists believe that the amount of solar radiation reaching the ground can be greatly reduced by introducing a cloud of fine dust into the upper atmosphere, and that this will lead to a reduction in the mean temperature of the earth. The eruption of the Krakatoa volcano in 1883 threw several cubic miles of debris into the air. This was followed by a reduction in solar radiation measured at the ground (*13*).

However, according to the best available information, there appear to be many orders of magnitude separating the amount of dust required to produce any significant reduction in the world-wide incoming radiation and that produced by the Nevada explosions.

Effects of the explosion itself. None of the scientists who replied to the inquiry about A-bombs and weather felt that the energy of the explosion could have a significant effect on the weather. A few comparisons between the energy of an A-bomb and natural phenomena can help explain their position.

The energy of a nominal A-bomb (equivalent to 20,000 tons of TNT) is 2×10^{13} cal. (*2*). This is divided into thermal and kinetic energy although the latter will also ultimately be converted into thermal energy. The thermal energy from the sun falling on 1 mi² of Nevada ground during an average spring day supplies as much heat as two nominal bombs. The energy released by the condensation of water in a typical thunderstorm is equivalent to 13 nominal bombs. Further comparisons with natural phenomena reveal similar statistics suggesting that the energy of an A-bomb, while tremendous compared with the energy of other man-made explosions, is relatively small compared with that of many natural phenomena.

The pressure wave emitted by the explosion may cause pressure changes that can be detected at a considerable distance. Figure 3 shows the response of the Bishop, Calif., barograph (about 80 mi from ground zero) to two of the explosions. The rise at 7:20 A.M., PST, 30 October 1951 resulted from an explosion at 7:00 A.M. But following an explosion at 7:30 A.M. 1 November 1951, for example, there was no detectable pressure change. In general, only a few of the shots have been recorded on the standard weather barographs outside of the proving ground. The movement of these pressure waves depended on the temperature and wind structure of the atmosphere as well as the force of the explosion.

Observational evidence. It may be argued that the weather is being modified by the A-bomb tests in spite of our finding no theoretical reason for believing this to be the case. It is therefore necessary to inspect climatic records to detect any changes in the weather that may reasonably be connected with the Nevada bomb tests.

The climatic element most often cited as having been changed by the atomic testing program in the United States is the frequency of tornadoes. The number of tornadoes reported in 1953 (532) exceeded the previous highest annual total by more than 200 and 686 were reported in the first 10 mo of 1954. An examination of the weather patterns for the spring months of 1953 indicates that 1953 had many features in common with several previous years of unusually

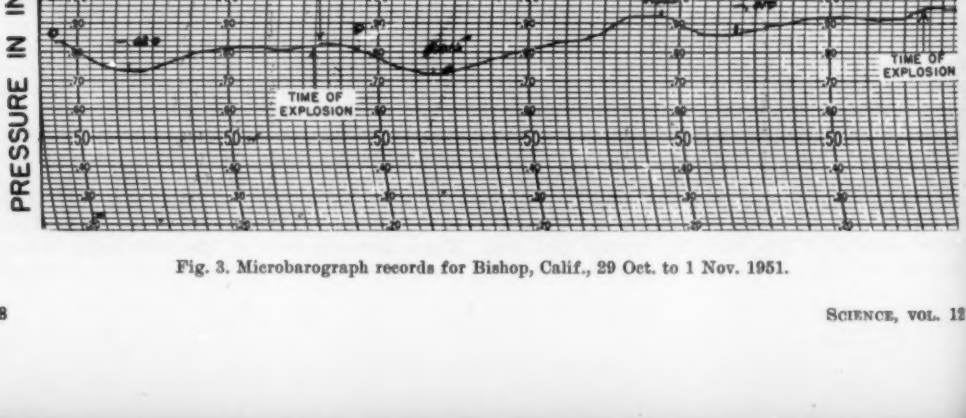

Fig. 3. Microbarograph records for Bishop, Calif., 29 Oct. to 1 Nov. 1951.

high tornadic activity, and it is likely that these favorable weather patterns contributed to making 1953 an unusual tornado year. A careful examination of the system for reporting tornadoes reveals considerable improvement since 1950, with perhaps the greatest improvement taking place in 1953 and continuing into 1954; it is believed that much of the increase in tornado reports can be traced directly to these changes (*14*).

Using the loss of life or property damage as a measure of tornado incidence, one finds that the loss of life in 1953, 516 persons, was exceeded on several occasions before 1950. The number of tornadoes doing more than $100,000 in damage, 43, was exceeded in 3 years before the beginning of atomic tests in Nevada, despite the increased property values in 1953. The total damage of 1953 did reach an all-time high of $224,345,900 because about seven tornadoes struck exceptionally valuable property. However *none* of these extremely damaging tornadoes occurred under the atomic cloud or in areas of relatively high fallout of radioactivity, and one occurred in December, more than 6 mo after the last atomic explosion in Nevada.

One significant feature of the 1953 tornado observations is the reporting of 133 tornado funnels that failed to touch the ground—more than ten times the average number of funnels aloft reported in earlier years (Fig. 4). This seems to be an indication of increased interest in tornado reporting.

A detailed study of the relationship between areas of radioactive fallout, or the presence of atomic clouds, and tornado occurrences reveals that there were relatively fewer tornadoes reported in areas of the atomic clouds or areas of large radioactive fallout than in areas of relatively small fallout. Furthermore, if one assumes that the increase in tornado reporting efficiency is approximately constant throughout any given year, the fraction of the annual number of tornadoes occurring during the Nevada test periods can be shown to be slightly less than in corresponding periods prior to 1950 (*14*). Neither of these statements is to be interpreted as proof that the presence of atomic debris inhibits tornadoes, but rather as convincing evidence that a case cannot be made for the A-bombs' increasing the likelihood of tornado occurrence.

The upper curve in Fig. 5 shows a plot of the monthly departure of the mean temperature of the entire United States from the average value for the period 1893–1950. The only record-breaking temperature in this curve since 1950 is the value of 42.9°F (8.4° above normal) in February 1954, which occurred many months after the last preceding Nevada atomic explosion. This curve shows the beginning of a trend toward warmer temperatures beginning early in 1951, and apparently continuing to the present. This is clearer in the curve for annual mean temperature shown in the lower part of Fig. 5. The heat released by an atomic bomb is certainly not enough to account for this warming; on the other hand, one of the most frequently suggested means by which the atomic bomb might affect the weather—by decreasing solar radiation—would imply lower, not higher, temperatures as the result of an atomic explosion. It may be noted that the trend toward warmer temperatures was even more pronounced during the period 1932–34.

The upper curve in Fig. 6 is a plot of the average monthly precipitation for the entire United States, plotted as a percentage of normal. The normal was computed from the data for the period 1893–1950. The only exceptional point on this graph since 1950 is the value of 26 percent of normal precipitation in October 1952. This was by far the driest month in the period of record. It occurred four months after the last atomic explosion in Nevada and at a period when there was little or no debris from atomic explosions over the United States. Although most suggested theories of the effect of atomic explosions on weather imply an increase in rainfall, this curve indicates a tendency toward drier than normal weather beginning in 1952. This trend can be seen more clearly in

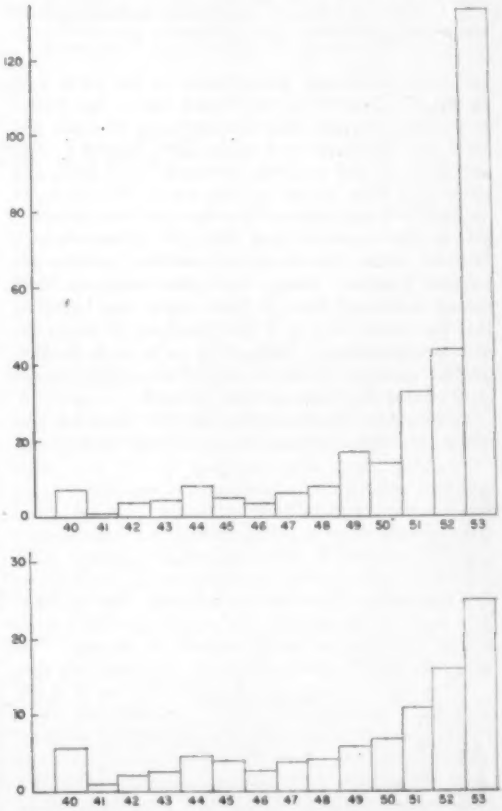

Fig. 4. Top: number (ordinate) of reported tornado funnels not touching the ground, 1940–53 (abscissa). Bottom: percentage (ordinate) of reported tornado funnels not touching the ground, 1940–53 (abscissa).

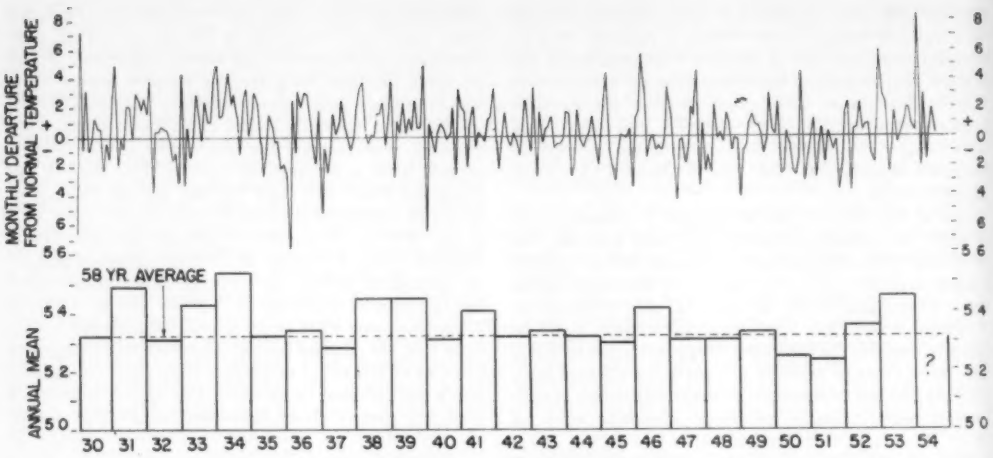
MONTHLY DEPARTURE FROM NORMAL TEMPERATURE
58 YR. AVERAGE
ANNUAL MEAN
?
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54

Fig. 5. Top: departure of the monthly mean temperature from the 58-year average. Bottom: average annual mean temperature, 1940–53.

the curve for annual precipitation in the lower part of Fig. 6. Rainfall in the United States has tended to be below normal since the beginning of 1952, and 1952 was the driest year since 1930. However, 1910 and 1921, as well as 1930, were drier than 1952, and there have been several periods since 1893 when the accumulated deficiency of precipitation was comparable to that recorded since 1952. The ultimate causes of these earlier periods of dry weather are also unknown. However, atomic explosions could not have caused them, and there is little reason for believing that the current dry spell has been brought on by the atomic explosions. A study of a series of individual weather stations reveals no results that differ significantly from the country-wide averages.

Pacific tests. This discussion has been limited to the effects of atomic explosions in Nevada because we have not yet examined sufficient data from the most recent Pacific tests to justify more than a tentative conclusion. However, a preliminary examination of the data does not indicate that any obvious changes in the weather have been produced by these explosions outside of the test area. The study of the data from these tests is being continued.

Conclusions. A number of suggested mechanisms by which atomic explosions might affect weather have been investigated and a study of climatologic data has been made to determine whether any weather anomalies exist that might be associated with atomic explosions. Although it is not possible to prove conclusively that atomic explosions have or have not influenced the weather, it is believed that this study has shown that such an effect is unlikely. The results of this study may be summarized as follows:

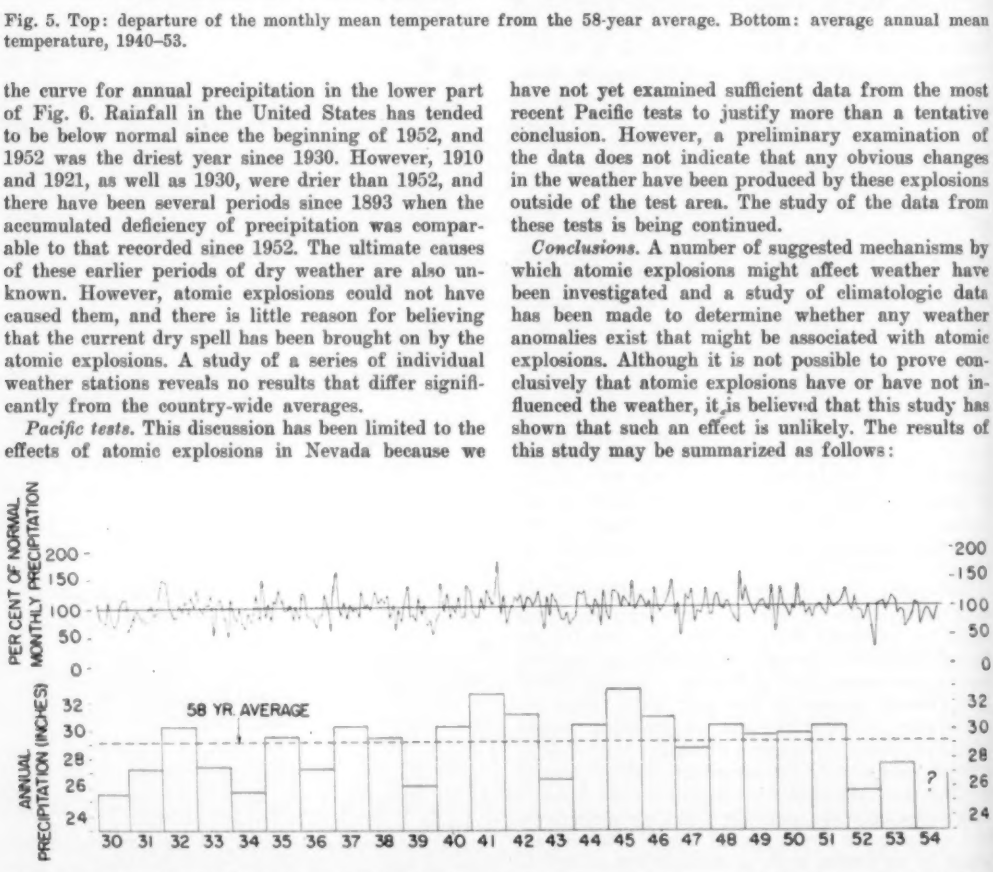
PER CENT OF NORMAL MONTHLY PRECIPITATION
58 YR. AVERAGE
ANNUAL PRECIPITATION (INCHES)
?
30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54

Fig. 6. Top: percentage of normal monthly precipitation. Bottom: average total annual rainfall for the United States, 1930–53.

1) No theoretical reason has been found for believing that any of the mechanisms examined could account for a significant change in the weather more than a few miles from the site of the explosion.

2) The year 1953 was an unusual tornado year. Although part of the increase in the number of tornadoes reported in 1953 may have been the result of exceptionally favorable weather patterns for tornadoes, much of the increase can be attributed to improvements in the method of collecting tornado statistics.

3) A study of the temperature and precipitation records for the United States does not seem to indicate any departures from normal that are related to the atomic explosions.

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4. We wish to express our appreciation to the Atomic Energy Commission for making available much of the data used in this study; to Vincent J. Schaefer for testing the nucleating effectiveness of the Nevada soil samples and for providing the records of ice nuclei observations at Mount Washington; to the personnel of the Cloud Physics Section of the Air Force Cambridge Research Center for testing the nucleating efficiency of soil samples and atomic radiations; and to the Carnegie Institution of Washington for permission to use the records of the Tucson Geomagnetic Observatory.
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6. Some writers distinguish between *freezing nuclei*, which cause existing water droplets to freeze, and *sublimination nuclei*, which permit the direct sublimination of water vapor. In this article both freezing and sublimination nuclei are referred to as *ice nuclei*.
7. V. J. Schaefer, *Bull. Am. Meteorol. Soc.* **35**, 230 (1954).
8. M. Eisenbud and J. H. Harley, *Science* **117**, 141 (1953).
9. It is noted that there are many ice nuclei counts of less than 500 or greater than 2000/m³, but almost none in between. The reason for this has not been explained, but it may be the result of the fact that one method of observation is used for high values and another for low values. Presumably no satisfactory techniques have been found for the in-between region. Thus the values of ice nuclei concentration below 1000/m³ are to be taken as indicative of rather low values and not as accurate measurements.
10. D. L. Harris, *J. Geophys. Research*, in press.
11. R. C. Callahan *et al.*, *ibid.* **56**, 545 (1951); R. C. Sagalyn and G. Faucher, *J. Atmospheric and Terrestrial Phys.* **5**, 253 (1954).
12. D. L. Harris, unpublished report on the effects of atomic explosions on atmospheric electricity.
13. W. J. Humphreys, *Physics of the Air* (McGraw-Hill, New York, 1940); H. Wexler, *Bull. Am. Meteorol. Soc.* **32**, 10 (1951); ———, *ibid.* **32**, 48 (1951); ———, *Sci. American* **186**, 74 (1952).
14. D. L. Harris, unpublished study of the effects of atomic explosions on the frequency of tornadoes in the U.S.

News and Notes

Macromolecular Chemistry

The international symposium on *Macromolecular Chemistry*, under the auspices of the International Union of Pure and Applied Chemistry (I.U.P.A.C.) and the Italian National Research Council (C.N.R.), was held in Milan 26–29 Sept. and in Turin 30 Sept.–2 Oct. 1954. In Milan the meetings were held at the Museo Nazionale della Scienza e della Technica and at the Instituto di Chimica Industriale del Politechnico di Milano. In Turin they were held at the Instituto dell' Università. The total number of registrants exceeded 300, representing Austria, Belgium, Canada, Czechoslovakia, England, Finland, France, Germany, Holland, India, Israel, Italy, Japan, Norway, Sweden, Switzerland, Union of Soviet Socialist Republics, the United States, and Yugoslavia. The United States was represented by P. J. Flory, Peter H. Frank, Robert W. Kell, H. B. Klevens, Gordon M. Kline, Edmund H. Immergut, Samuel L. Madorsky, Herman Mark, Robert B. Mesrobian, Eric Proskauer, Walter H. Stockmayer, and C. A. Y. Voetelink.

The symposium was opened in Milan by addresses of welcome by V. Ferrari, lord mayor of Milan, by Luigi Morandi, president of the Lombard section of the Italian Chemical Society, and by M. G. Levi, president of the Italian Chemical Society. Herman Mark, who is chairman of the committee of macromolecular chemistry of the I.U.P.A.C., was awarded a scroll of honorary membership of the Italian Chemical Society, after which he presented an illustrated talk on "New rubbers, plastics, and fibers."

The meeting in Turin was opened with addresses of welcome by A. Peyron, lord mayor of Turin, G. Camerana, president of Salone della Technica, and A. Muzzoli, president of Congresso Materie Plastiche. H. Mark then spoke on the "Scientific basis of standardization of plastics."

There were about 80 papers presented, in five different languages: English, French, German, Italian, and Russian. These papers covered the following general subjects: (i) building reactions of macromolecules; (ii) transformation reactions of macromolecules; (iii) block polymers and graft polymers—preparation and properties; (iv) cellulose and derivatives; (v) molecular weight distribution; (vi) methods for the determination of molecular weight; (vii) branched polymers; (viii) fiber-forming polymers; (ix) general properties of polymers; (x) crystallinity and transitions; and (xi) proteins. The papers and discussions will appear shortly as a special issue of *La Ricerca Scientifica* and will be distributed through the Interscience Publishers, 250 Fifth Ave., New York.

At the meeting in Milan, Herman Mark was awarded a medal by the Instituto di Chimica Industriale del Politechnico di Milano; this is the first time the medal has been awarded to a non-Italian. Also, at the meeting in Turin, H. Staudinger was awarded a degree *honoris causa* of the University of Turin, after which he gave an address on the subject "Über die Grundlagen der macromolekularen Chemie."

The next meeting of the Macromolecular Commis-

sion will be held in Zurich, Switzerland, during the period 20–28 July 1955.

S. L. MADORSKY

National Bureau of Standards, Washington 25, D.C.

Improving Biology Teaching

The Southeastern Work Conference on Biology Teaching, held at the University of Florida from 28 Aug. through 6 Sept. [*Science* **120**, 653 (1954)], had four major objectives: (i) to study the contributions of various subject-matter areas of biology (taxonomy, morphology, evolution and paleontology, physiology and health, heredity and development, and ecology and conservation) to the training of the biology teacher and to suggest the basic principles, concepts, and experiences by which these contributions could be realized; (ii) to identify the major problems involved in biology teaching at the high-school and college levels and in establishing state-wide programs on biology teaching; (iii) to formulate recommendations for the improvement of biology teaching; and (iv) to devise methods for implementing the recommendations of the conference. The purpose of this report is to call attention to the most significant of these recommendations.

The conferees agreed on certain minimum essentials that the high-school biology course should provide all students.

The minimum essentials are (i) an understanding of the basic principles of biology that are essential to effective living in modern society; (ii) an understanding of themselves and of the human life-cycle; (ii) an understanding of how the organisms and physical environment in a given situation form a community with many complex relationships; (iv) an understanding of the usefulness of biology in later life and an appreciation of the possibility that they may contribute to its advancement; (v) an understanding of scientific methods and attitudes; (vi) a positive approach to physical and mental health (vii) the contribution that living things can make to the development of avocational interests.

It was further felt that biology should be integrated into the total secondary-school program. Since knowledge is not self-integrating, such integration cannot be taken for granted. Both teacher and student must work at it.

In order to bring this integration about, the conference recommended that (i) biology teachers have a general knowledge of other areas and that teachers in other areas have some knowledge of biology; (ii) the objectives of the biology course make a significant contribution to the general objectives of the school; (iii) situations be created to encourage individual, group, and class projects to culminate in assembly programs, exhibits for science fairs and meetings of Junior Academies of Science, and other school activities; (iv) interdepartmental planning be encouraged; (v) students be given an opportunity to apply in other classes what they learn in biology.

A number of suggestions were made to illustrate how biology may be integrated with other high-school subjects.

Some of these suggestions were (i) the use of biological information in English themes; (ii) the use of biological data in making curves and graphs in mathematics courses; (iii) the evaluation of health problems, natural resources, and agricultural productivity in social science; (iv) the study of the derivation of biological terminology in language classes; (v) the use of biological topics in speech work; (vi) the use of plant and animal forms and patterns of structure in art; (vii) the relationship of human reproduction to family life and social welfare; (viii) the use of human physiology in physical education; and (ix) the application of biological knowledge concerning the selection, care, and use of foods to home economics.

One of the major recommendations of the conference related to the preparation of the high-school biology teacher. It was recognized that any recommendation for a balanced program would leave much to be desired if the teacher is to be prepared in 4 yr. However, it was felt that a realistic view of the high-school teaching situation as it exists now and will exist for some time to come required the conference to think in terms of a 4-yr program.

In order to provide the best possible training in such a program, the conference recommended that the prospective high-school biology teacher have (i) a college major, that is, a minimum of 24 semester hours, in the biological sciences that includes 1 yr of general biology, or equivalent courses in general botany and general zoology, with at least one-third of the total content devoted to plant science and with field studies included in the course work beyond the first year; (ii) 1 yr of chemistry with the recommendation that organic chemistry as it applies to living things be included; (iii) 1 yr of physics with laboratory work; (iv) ½ yr of earth science; (v) 1 yr of mathematics; (vi) education courses to meet state certification requirements with a course in the methods of teaching high-school biology strongly recommended; (vii) appropriate general-education courses (humanities, social sciences, and communication skills) that are required of other high-school teachers.

These requirements were recommended as the minimum in training an effective high-school biology teacher. The biology teacher who meets these qualifications will have a background for teaching general science and assuming the multiple responsibilities of the science teacher in a small high school. The conference was particularly sensitive on the subject of the high-school science teacher whose major interest is not science. It was agreed that through local and state effort this situation should be improved, reduced, and as soon as possible eliminated.

It was recognized that preservice training is not adequate for a lifetime of effective high-school biology teaching. Continuous self-improvement through in-service training is essential.

It was felt that such in-service activities might include (i) graduate study in biology, related sciences, science education, or professional education, depending on the needs of the teacher; (ii) individual study of scientific and professional literature; (iii) travel, especially to regions of biological interest; (iv) contacts with college

and university laboratories, greenhouses, experimental farms, libraries, and other facilities for professional improvement; (v) participation in local and state-wide, teacher-planned, in-service programs; (vi) use of consultants from colleges and universities, industrial and social agencies, and state departments of education and other government agencies; (vii) conferences, workshops, professional meetings, and intraschool and interschool visitations; (viii) participation in professional and scientific organizations at the local, state, regional, and national levels; (ix) participation in research in pure science or in science education.

It was felt that the colleges and universities could contribute more effectively to the in-service training of the high-school biology teacher.

To this end, the conference recommended that the colleges and universities (i) consider the possibility of offering a wider variety of biology courses during the summer session and explore, with the cooperation of certification agencies, the feasibility of offering extension courses; (ii) arrange annual 1-wk conferences for high-school biology teachers that will provide suggestions for the use of simple materials, demonstrate new types of experiments, give additional background, and call attention to recent developments; (iii) offer appropriate credit to teachers for courses at any level; (iv) design special subject-matter courses for teachers and schedule them at appropriate times; (v) give full resident credit for workshops and work conferences that are comparable in length and quality to standard courses.

The conference attacked the problem of provisional and temporary certification for high-school biology teachers who do not meet the minimum requirements.

In this area, the conference recommended that (i) provisional certificates be issued only when the local superintendent can certify the lack of a qualified teacher; (ii) holders of such certificates be required to become qualified as soon as possible through summer study; (iii) provisional certificates be issued on a 1-yr basis and be renewed only upon presentation of evidence of satisfactory progress toward meeting full certification requirements; (iv) programs be established within the school or local system, in collaboration with nearby colleges and state science supervisors, that will provide for the immediate and continuing in-service training of teachers who hold provisional and temporary certificates; (v) teachers be encouraged to enroll in formal courses selected from the teacher-training program on which full certification is based.

It was also agreed that in the selection of a biology teacher where there is a choice between a prospect with sound training in biology but without professional courses in education and one with a certificate but no biology training, the former should be given preference.

The conference recommended that state departments of education employ well-qualified science coordinators, advisers, or consultants who have had high-school experience and who are trained in both science and education to consult with science teachers in the high schools and to implement a program of cooperation between college scientists and high-school teachers. It was pointed out that the appropriate agency or persons in state departments and colleges should assist in obtaining an hour-for-hour allocation of teaching credit for laboratory instruction.

The conference felt that the state departments of education should play a significant role in insuring a supply of adequately prepared high-school biology teachers.

It was recommended that (i) state departments of education adhere to certification requirements that will insure the minimum training indicated and content areas be adequately represented on commissions that establish certification requirements; (ii) science consultants in state departments actively supervise science teaching in high schools; (iii) state departments refuse to certify persons unless they have had the college courses in biology that adequately cover the areas represented in the high-school biology course; (iv) state departments cooperate with the colleges in setting up approved programs for teachers that will give broad training in science and mathematics in addition to a balanced general education, and that will enable the teacher in the small school to teach in more than one area.

It was believed that state departments of education could also aid in the recruitment, selection, and motivation of high-school and college biology teachers.

To fully realize this goal, the conference recommended (i) the establishment of adequate salary scales to attract and retain qualified teachers in the profession; (ii) the establishment of suitable retirement benefits; (iii) the maintenance of active in-service training; (iv) the establishment and maintenance of a research staff to evaluate and suggest improvements in methodology; (v) the encouragement of democratic school administration; (vi) the encouragement of and assistance in obtaining the best classroom instruction possible; (vii) the encouragement of local communities in their efforts to obtain high-caliber instruction; (viii) the encouragement of administrative officials and advisers to present the teaching profession as an attractive career opportunity to biology majors.

As one would expect, the conference considered the problem of improving the working relationship between the biologist and the professional educator in the training of biology teachers. It was agreed that the effective high-school biology teacher must be trained in subject matter. However, it was further recognized that in order to be effective the high-school biology teacher must be familiar with the areas of adolescent growth and development, the objectives of the total high-school program and the relationship of the biology course to it, the methods of working with boys and girls of high-school age, and the techniques of evaluating student progress. Traditionally, content has been the sphere of the specialist in biology while method has been the province of the professional educator. Too often each has operated independently. It was the opinion of the conference that the best teachers could be produced only when the biologist and the educator worked together.

In order to bring about more effective working relationships, the conference recommended that (i) work conferences be organized at the local, state, regional, and national levels to provide an opportunity for scientists and

educators to discuss their mutual problems; (ii) biology departments be given the responsibility of teaching "methods" courses that carry education credit; (iii) the biologist be encouraged to observe and work with student teachers of biology for whose "content" he is responsible; (iv) the training and experience of the biologist be used in planning education courses, especially when they deal with such problems as human physiology and genetics; (v) both the professional educator and the specialist in biology participate cooperatively in teacher training through joint decisions concerning certification, student advising programs, evaluation of student programs, evaluation of teaching effectiveness, and provision of content material; (vi) there be mutual action by educators and biologists in promoting organizations of high-school students interested in science; (vii) opportunities be provided for exchange teaching assignments between educators and biologists.

The complete report of the conference appears in the January issue of the *American Biology Teacher*, official publication of the National Association of Biology Teachers, cosponsor with AIBS of the conference. State teams representing each of the ten southeastern states have been organized to adapt the recommendations of the conference to their own needs and to implement the recommendations, and they are now at work. Although it is too early to evaluate the results, the conference promises to have far-reaching effects. It has drawn the plans and laid the foundation on which significant advances in biology teaching can be constructed.

SAMUEL L. MEYER

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Science News

The following 10 major **gains in the fight on cancer** during the past 2 yr are cited in the 1952–54 biennial report of Memorial Center for Cancer and Allied Diseases with its research unit, the Sloan-Kettering Institute, New York.

1) The mass and sustained growth, for the first time, of human cancers in laboratory animals.

2) Improvement from 6 percent to 39.5 percent in cure rates for soft tissue sarcomas over the past 20 yr.

3) Synthesis by the Wellcome Research Laboratories of 6-mercaptopurine, a chemical that appears from tests at Memorial to be one of the most effective in restraining acute leukemia.

4) An increase through the years from 10 to 75 percent in the number of patients with cancer of the stomach who can be treated surgically.

5) Establishment of circumcision of male infants as a practical means for partial prevention of cervical cancer in women.

6) Improvement in techniques of surgery of the liver permitting removal of cancer in this vital organ in some selected cases.

7) Development of effective treatment for formerly uncontrollable small blood vessel tumors (hemorrhagic telangiectasia).

8) Adaptation of a virus to destroy, rapidly and completely, human cancer cells of one type in the test tube.

9) Definition of two types of breast cancer, requiring different treatment.

10) Discovery that cortisone, as well as sex hormones, will temporarily control some advanced breast cancers.

At the 121st annual meeting of the American Association for the Advancement of Science, Farrington Daniels, University of Wisconsin chemist and chairman of the board of governors at the Argonne National Laboratory, stated that "stepped-up research in atomic energy is the most hopeful way of eventually mastering the problem of the **world's dwindling fuel supplies.**" He also predicted that energy from the sun may be one of the future substitutes for coal, oil, and gas, the three fossil fuels which are running out at a rapid rate. Daniels further said that "our civilization is due to cheap energy and we haven't yet learned how to live on our current income of daily sunlight."

In her inaugural address to the second All-India Conference on Family Planning that met in Lucknow on 1 Jan., Dhanvanthi Rama Rau, a leader in social reform, sharply criticized the Government for pursuing an "inconsistent" policy in advocating **family planning** without carrying out an effective birth-control program. She pleaded for the establishment of a factory for large-scale manufacture of contraceptives and suggested spreading birth-control information through all possible channels.

Contrary to expectations, religious beliefs have not presented a formidable obstacle in popularizing family planning among the traditionally conservative village folk. Surveys have indicated that 40 percent of the people in the country and 60 percent of the urban population are interested in birth control.

On 26 Dec. a group of **Japanese atomic scientists** left Tokyo by air for a 3-mo survey of atomic energy development in 12 countries.

The **population of the United States**, including members of the armed forces overseas, rose to 163,930,000 at the end of 1954. This represents a gain of 2,830,000 during the year and exceeds by more than 100,000 the previous high gain registered in 1951. It was the eighth year in succession in which the population increase has been more than 2.5 million. Contributing to the 1954 rise were the new high number of births (4,060,000), an all-time low death rate, and a moderate addition through immigration.

Every state except West Virginia shared in the 1954 population increase. The rate of growth was highest along the Pacific Coast, 3.7 percent, or approximately double the national gain of 1.8 percent. Since April 1950 California alone has added more than 2.3 million inhabitants. Its population now numbers about 12.9

million and is exceeded only by that of New York State.

The Rocky Mountain states also experienced a vigorous population growth during the year. Arizona and Nevada have been the fastest growing states in the country, each having doubled its population since 1940.

Florida's population increased by about 5.7 percent in 1954 and by more than 6 percent annually in the years immediately preceding. Increases well above the national average also occurred in the District of Columbia and in New Mexico, Delaware, Maryland, Utah, Connecticut, Michigan, Louisiana, and Texas.

The marriage rate declined to 9.2 per 1000 population. Low birth rates in the depression 1930's are responsible. Divorces were also on the decline, according to the figures for the first 9 mo of 1954. Since the 1946 peak, these rates have dropped more than 40 percent.

Columbia University oceanographers have announced the discovery of **100-million-yr-old fossil sea animals** at the bottom of the Atlantic Ocean. Muddy sediments or "cores" taken from the bottom off Bermuda during the latest voyage of the university's research ship *Vema* were found to contain the ancient fossils. According to W. Maurice Ewing, director of Lamont Geological Observatory, Palisades, N.Y., nothing older than these core samples has been found in any ocean. Probing was concentrated in the 20 by 30 mi expanse that lies over the Bermuda "plateau" and brought up the fossil remains of an extinct shell fish *Inoceramus*.

The U.S. Department of Agriculture has announced that the first **burley tobacco**, Burley 21, with a marked resistance to the wildfire disease will be available to growers for 1955 planting. The new tobacco variety, which was developed by the USDA Research Service and the Tennessee Agricultural Experiment Station, is also resistant to two other diseases, tobacco mosaic and black root rot.

In addition to its disease-resistant qualities, Burley 21 is a stand-up variety that hold its leaves more erect than any other burley now available. This makes it easier to cultivate and harvest without breaking the leaves.

John Stanwell-Fletcher, who as an Air Force officer during World War II helped set up arctic weather stations and landing strips, is to lead a privately financed **expedition to the North Pole** that is scheduled to leave Alert, Canada, on 17 or 18 Mar. The main purpose of the 2- to 3-wk operation is to perfect an instrument by which planes can gage from the air the thickness of arctic ice and, therefore, its suitability for landings. Stanwell-Fletcher has been working on such a device in collaboration with Leonard P. Freider, president of General Textile Mills, Inc., and one of the chief backers of the trip. The idea for the instrument came from a Russian device developed in 1937. Russian scintific papers concerning it were found in the Library of Congress and translated.

An experimental plane, the Burnelli Loadmaster, has been selected to land the main party of 20 persons and 41 dogs. The unconventional plane, which is rather like a flying wing, requires only 1500 ft to take off or land. Further, its fuselage is said to have buoyancy in case of a forced landing on water.

Scientists in the News

Renfrew B. Potts, Australian physicist and senior lecturer in mathematics at the University of Adelaide, has been appointed a research associate in the physics department of the University of Maryland. Potts came to the U.S. under a Fulbright grant; he will work with the university's solid-state theory group under Ralph Myers and Elliott Montroll on investigations in ferromagnetism and other solid-state theory problems. The solid-state research group is supported by the Office of Scientific Research of the Air Research and Development Command of the U.S. Air Force.

John R. Hastie, a member of the Cornell University research office since 1951, will succeed to the post of coordinator of research early in 1955, following the retirement of **Richard Parmenter**, the present coordinator. Parmenter plans to continue certain consulting assignments and to assist the university in special projects. He was instrumental in setting up the Cornell research program, which involves more than $20 million/yr. Hastie's chief function will be to act as a coordinator between faculty members engaged in research and the sponsoring foundations, industries, and government agencies.

Edwin H. Buford, since 1950 manager of engineering design in the general engineering department of the Chemstrand Corp., Decatur, Ala., retired on 31 Dec. He had served in a similar capacity with Monsanto Chemical Co. for 35 yr.

Paul B. Sears, botanist and chairman of the conservation program at Yale University, was selected as president-elect of the AAAS during the recent annual meeting in Berkeley, Calif.

New members of the board of directors are **Margaret Mead**, anthropologist and associate curator of ethnology for the American Museum of Natural History, New York, and **Chauncey D. Leake**, physiologist, pharmacologist, and executive director of the University of Texas Medical Branch, Galveston.

Charles B. Officer, geophysicist with the Woods Hole Oceanographic Institution, was selected as 1954–55 distinguished lecturer by the Society of Exploration Geophysicists. During December and January he has been delivering lectures on seismic exploration and research over oceanic areas before 12 local sections of the society.

The 1955 Rumford medal of the American Academy of Arts and Sciences has been awarded to **James Franck** of the University of Chicago, a 1925 Nobel prize winner. Given for the year's most important discovery or useful improvement in the field of light or heat, Franck was honored for his work in photosynthesis.

On 1 Jan. Queen Elizabeth II named three new barons; one of them was **Edgar Douglas Adrian,** president of both the Royal Society and the British Association for the Advancement of Science. Among those receiving other honors from the Queen was **Wilfrid Clark,** who denounced the Piltdown skull as a hoax. He now is a knight bachelor.

Allen V. Astin, director of the National Bureau of Standards, who last year was discharged and reinstated as the result of a controversy concerning the merits of battery additive AD-X2, has been reappointed by the President as chairman of the Federal Interagency Committee on Scientific Research and Development.

Robley C. Williams, biophysicist at the University of California Virus Laboratory, was selected by the Philadelphia Board of City Trusts as this year's recipient of the John Scott award. He was cited for his invention of a method of depositing thin metal coatings by thermal evaporation on objects to be examined with the electron microscope, making it possible to get a clear picture of viruses and other transparent objects. The award, consisting of $1000, a copper medal, and a scroll, was presented on 28 Dec. during the annual meeting of the AAAS.

Phillip L. Merritt, assistant director for exploration in the Atomic Energy Commission's division of raw materials, has resigned to accept a position as senior geologist with E. J. Longyear and Co., Minneapolis, Minn. He will maintain offices in New York.

Five chemists were awarded honorary degrees at the University of Chicago's 263rd convocation in December. They are **Hermann I. Schlesinger,** professor emeritus of chemistry at the University of Chicago; **Izaac M. Kolthoff,** professor of chemistry at the University of Minnesota; **George O. Curme,** vice president and member of the board of directors of the Union Carbide and Carbon Corp.; **Paul D. Bartlett,** Erving professor of chemistry at Harvard University, and **John G. Kirkwood,** chairman of the chemistry department, Yale University.

The seven experts appointed to the United Nations committee that will make preparations for the proposed international conference on peaceful uses of atomic energy are as follows:

Dmitri V. Skobeltzin, physicist and a leading member of the Soviet Academy of Science.

John Cockcroft of Great Britain, a Nobel prize winner in physics and since last August a member of the United Kingdom's Atomic Energy Authority. His alternate, J. V. Dunworth, is deputy chief of the science office in the British Ministry of Supply.

Wilfred Bennett Lewis, whose alternate is David J. Keys; both men are vice presidents of research and development in the Canadian Atomic Energy Authority at Chalk River.

Bertrand Goldschmidt, a member of the French Atomic Energy Commission and head of its general physics service. His alternate will be Jacques Tine, a member of the French delegation to the UN.

Homi Bhabha, chairman of the Indian Atomic Energy Commission and a fellow of the Royal Society of Britain.

Jame de Barros of the UN delegation from Brazil. His alternate will be Joaquim Coste Ribeiro.

I. I. Rabi, Higgins professor of physics at Columbia University.

Eric J. Hewitt, vice president of Evans Research and Development Corp., New York, has been appointed to the subcommittee on general products of the Advisory Board on Quartermaster Research and Development of the National Academy of Sciences–National Research Council. The appointment is for 3 yr.

Necrology

Liberty H. Bailey, 96, botanist, horticulturist, author, editor, former president of the AAAS, and dean emeritus of the College of Agriculture at Cornell University, Ithaca, N.Y., 25 Dec.; **Charles Belknap,** 74, former president of Monsanto Chemical Co., St. Louis, Mo., 29 Dec.; **Arthur C. Bent,** 88, author and former associate in ornithology at the Museum of Comparative Ornithology, Harvard University, Cambridge, Mass., 30 Dec.; **Shanti S. Bhatnagar,** 59, chemist, author, former president of the National Institute of Sciences of India, and secretary of the Ministry of Natural Resources and Scientific Research, New Delhi, India, 1 Jan.; **William M. Burton,** 89, chemist, pioneer in petroleum refining technology and retired president of the Standard Oil Co. (Ind.), Miami, Fla., 29 Dec.; **Francis L. Castleman,** 52, dean of the School of Engineering at the University of Connecticut, Storrs, 30 Dec.; **Richard Flack,** 81, authority on fungi and former professor of applied mycology at the University of Göttingen in Germany, Atlanta, Ga., 1 Jan.; **Charles J. Foote,** 93, former instructor in clinical medicine at Yale Medical School, New Haven, Conn., 29 Dec.; **Edmund N. Gathercoal,** 80, author, past president of the American Pharmaceutical Assoc., and emeritus professor of botany and pharmacognosy of the School of Pharmacy at the University of Illinois, Urbana, 27 Dec.; **Annie W. Goodrich,** 89, retired dean of the School of Nursing at Yale University, New Haven, Conn., 31 Dec.; **Arthur C. Parker,** 73, anthro-

pologist, archeologist, ethnologist, author, and retired director of the Rochester Museum of Arts and Sciences, Rochester, N.Y., 1 Jan.; **Samuel M. Seidlin,** 59, endocrinologist, author, pioneer in the use of radioisotopes in thyroid diseases, chief of the Endocrine Clinic and Medical Physics Research Laboratory at Montefiore Hospital, New York, 2 Jan.; **Calvin P. Stone,** 62, authority on sex behavior and genetic psychology, author, editor, past president of the American Psychological Assoc., and professor of psychology at Stanford University, Calif., 28 Dec.; **Ernest V. L. Whitechurch,** 80, former instructor in operative dentistry at Harvard University, Boston, Mass., 28 Dec.

Meetings

The 9th annual **M. D. Anderson Symposium on Fundamental Cancer Research** will be held 10–12 Mar. at the University of Texas M. D. Anderson Hospital and Tumor Institute in the Texas Medical Center, Houston. The first day of the program will be a review of the current research projects at the hospital. This will be followed in the evening by the first formal gathering for the symposium—a discussion of the epidemiology of cancer by Eleanor Macdonald and a presentation on experimental design by John Fertig, professor in the department of statistics, Columbia University Medical School.

The second day of the symposium will be devoted to histochemistry. George Gomori of the University of Chicago, chairman of this program, has chosen six national figures as speakers. On the final day there will be presentations reflecting current cancer research in the Southwest; A. Clark Griffin of M. D. Anderson Hospital has assembled an interesting series of papers.

The Southeastern Section of the **American Society of Plant Physiologists** is holding its annual meeting at Louisville, 7–9 Feb. In addition to a program of contributed papers, two symposiums are to be held under joint sponsorship: The first with the American Horticultural Society and the second with the American Society of Agronomy.

Symposium I is on *Growth and Development of Plants with Special Reference to Temperature and Light,* Aubrey W. Naylor, Duke University, presiding. Participants will be H. A. Borthwick, A. C. Leopold, J. P. Overcash, J. L. Liverman, and Tokuji Furuta. Symposium II is entitled *Plant-Soils-Water,* P. J. Kramer, Duke University, presiding. Participants will be V. C. Jamison and Charles W. Domby (joint presentation), Hilda F. Rosene, and D. E. McCloud.

At the annual breakfast John W. Mitchell, U.S. Plant Industry Station, Beltsville, Md., will deliver an address on "Agricultural applications of growth regulators." Further information may be obtained from Dr. Wayne C. Hall, Dept. of Botany, A. and M. College of Texas, College Station, Texas.

A report on the Bayreuth meeting of the German Bunsen Society for Physical Chemistry is included in *Zeitschrift für Elektrochemie und Angewandte Physikalische Chemie* (No. 8, vol. 58, 1954). Although the main theme of the meeting was **nuclear chemistry,** the statistics given in the introduction of the article are of interest not only to chemists but also to physicists, biologists, and other scientists. *Chemical Abstracts* in 1951 had 2000 reviews on nuclear chemistry as compared with 790 in electrochemistry and 160 in photochemistry. Even analytic chemistry with only 900 reviews and inorganic chemistry with 570 indicate that nuclear chemistry has become one of the most intensely active fields in all of chemistry.

The meeting opened with a paper by Otto Hahn, Nobelist from Göttingen, entitled the "Development of nuclear chemistry—reminiscences," showing how modern nuclear chemistry is a direct outcome of the classical studies of radioactivity. The report then presents a discussion of "Nuclear structure and nuclear transformations" by H. T. Jensen of Heidelberg, and of "Nuclear binding energies," with illustrations from mass spectroscopy, by J. Mattauch. Next follows an article by Alfred O. Nier of the University of Minnesota on the "Determination of isotopic numbers and mass dependence by mass spectroscopy."

F. A. Paneth discusses the helium method for the determination of the age of iron meteorites; W. F. Libby, the newly elected commissioner of the U.S. Atomic Energy Commission, contributes a comprehensive review on carbon dating; and R. Brill of Brooklyn Polytechnic considers "Crystal structure examination by neutron diffraction." A large number of other articles covering such subjects as the application of tracers, the emanation method of Hahn, adsorption and desorption, and the nuclear shell model make this one of the most interesting publications recently available in the new field of nucleonics and nuclear chemistry. The issue also carries a handsome portrait of Max von Laue in recognition of his 75th birthday on 9 Oct. 1954.

Many prominent leaders of American industry, education, government, and the military, will assemble in Chicago, 10–11 Feb., to attend the **Military-Industrial Conference** at the Conrad Hilton Hotel and discuss the utilization of engineers and scientists in the military and in industry. Participation is invited. Copies of the program will be mailed upon request to: Military-Industrial Conference, Room 1191, 140 S. Dearborn St., Chicago 3, Ill. The meeting is being sponsored by the Society of American Military Engineers with the support of leading industrial, governmental, and professional organizations. Organization of the conference has been prompted by an awareness that, with the expiration of the Selective Service law in June 1955, another bill dealing with military manpower will be introduced in the Congress. This bill will have far-reaching effects on the future welfare of this country and will require exhaustive reconsideration of the entire manpower policy.

Ninety sessions, at which most of the 40 committees in the five technical divisions of the **American Institute of Electrical Engineers** will present papers on the latest discoveries and advancements in their profession, will be held during the winter general meeting of the institute at the Statler Hotel, New York, 31 Jan.–4 Feb. It is expected that the registration of 5000 at the last winter meeting, which set an all-time record, will be exceeded.

The Potomac Division of the **American Phytopathological Society** will meet 3–4 Mar. at the Plant Industry Station, Beltsville, Md. Papers of general interest will be delivered on the first day and a fungicide symposium, *Fungicides—Past, Present, and Future,* will be held on the morning of the second day. This symposium will be moderated by J. W. Heuberger, and the speakers are George L. McNew, director of the Boyce Thompson Institute for Plant Research; Hubert Martin, formerly of England and now director of the Science Service Laboratory, London, Ontario; T. Walter Reed, assistant manager of research, California Spray Chemical Corp.; and Lea S. Hitchner, executive secretary of the National Agricultural Chemicals Assoc. Hitchner will place emphasis on the recently passed Miller bill. The speaker for the annual banquet will be Karl D. Butler, a well-known plant pathologist with a number of years' experience in state experiment stations in the tropics for the U.S. Department of Agriculture.

The **Sixth Alaskan Science Conference** sponsored by the Alaska Division, AAAS, will be held at the University of Alaska at College, 1–4 June 1955. Organizing chairmen for the six sections of the conference are

Agriculture and Forestry—Arthur W. Greeley, regional forester, U.S. Forest Service, Juneau
Biological sciences—Andres I. Karstens, commanding officer, Aeromedical Laboratory, Ladd Air Force Base
Physical sciences—Chas. Genaux, chemistry dept., Univ. of Alaska
Engineering—A. F. Ghiglione, commissioner of roads, Alaska Road Commission, Juneau
Medicine and public health—Earl Maxwell, surgeon, Elmendorf Air Force Base, U.S. Air Force
Social sciences—Margaret Lantis, anthropologist, U.S. Dept. of Health, Education, and Welfare, Anchorage

Anyone wishing to present a paper at the conference is asked to contact the appropriate chairman by *15 Feb. 1955.*

The **National Conference on Transistor Circuits** will be held in Philadelphia, 17–18 Feb., under the joint sponsorship of the Institute of Radio Engineers Professional Group on Circuit Theory, the Science and Electronics Division of American Institute of Electrical Engineers, and the University of Pennsylvania. The 1955 conference is patterned after the first one held at the same location a year ago and will consist of four consecutive sessions with papers covering both linear and nonlinear transistor circuit applications. Emphasis will be on material not previously available in the literature, and the program is designed to be of greatest value to engineers who already possess some knowledge of transistor circuit behavior. Authors are encouraged to publish subsequently in professional journals in lieu of conference transactions.

One innovation being considered this year is an evening session of informal round-table discussions. It is requested that those interested in participating write the chairman of the program committee, H. E. Tompkins, Burroughs Research Center, Paoli, Pennsylvania, indicating discussion topics. Anyone interested in attending who has not received registration forms should request them from Mr. W. J. Popowski, Minneapolis-Honeywell Regulator Co., 176 West Loudon St., Philadelphia 20, Pa.

The organizing committee of the 14th **International Congress of Pure and Applied Chemistry,** to be held in Zurich, 21–27 July, has announced that the final date for registration is 15 Feb. The committee adds that technical reasons prevent further postponement.

The 7th annual convention of the **International Academy of Proctology** will take place at the Plaza Hotel in New York, 23–26 Mar. 1955. The international, national, and local program committees are planning an unusual seminar on anorectal and colon surgery. There will be special emphasis on anorectal presentations and on panel discussions, as requested by those who attended the Chicago meeting in 1954. Plans are being developed for wet clinics and lectures at the Jersey City Medical Center under the direction of Earl Halligan, surgeon-in-chief of the Medical Center.

Speakers from this country and from abroad will present papers and motion-picture demonstrations of their personal techniques. Mexico is expected to be very well represented at this meeting. All physicians and their wives are cordially invited to attend the convention, whether or not they are affiliated with the academy. There is no fee for attendance.

Education

On 2 May the Special Training Division of the Oak Ridge Institute of Nuclear Studies will open a special 4-wk basic course in the **techniques of using radioisotopes,** to be offered especially for scientists and technicians from among the 53 countries eligible to receive shipments of isotopes from this country. The course is the first of several supporting projects launched under the auspices of the Atomic Energy Commission in furtherance of President Eisenhower's proposal for an international atomic agency. Like the regular basic courses, this class will be limited to 32.

Qualifications for prospective enrollees are a bachelor's degree, adequate training and experience in the

field in which they propose to use isotopes, and an understanding of the English language. Application forms, which must be submitted before 1 Feb., are available at U.S. embassies and legations, or may be obtained from the Special Training Division, Oak Ridge Institute of Nuclear Studies, P.O. Box 117, Oak Ridge, Tenn.

Formal dedication of the new $1.5 million **engineering building of Johns Hopkins University** will be held in the spring of 1955. The building, which will be named Ames Hall in honor of Joseph Sweetman Ames, former president, completes the group of major buildings on the main quadrangle of the Hopkins campus. All departments are expected to be completely in operation in the new structure by the end of the year.

The **largest radiotelescope** in the United States, a steerable parabolic antenna 60 ft in diameter, will be built at the Agassiz Station of Harvard College Observatory. The National Science Foundation is expected to help support its construction, scheduled to begin shortly; an anonymous benefactor will also contribute. The largest radiotelescope of this saucer variety now in use, which is operated by the Naval Research Laboratory in Washington, D.C., is 50 ft in diameter. However, two larger antennas of the same kind are now being built abroad. The Dutch are constructing a 75-ft instrument, and the British are building a 250-ft one that is scheduled for completion next year.

Approximately $1 million for a new geology building is being given to the **Rice Institute** by the three daughters of the late Harry C. Weiss, Mrs. James A. Elkins, Jr., Mrs. William Francis, Jr., and Mrs. Lloyd Smith. The actual structure will cost in the neighborhood of $750,000 and is expected to be ready for use by the fall of 1956. It will house the Harry C. Weiss chair of geology established in 1952 by Mrs. Weiss as a memorial to her husband. Mr. Weiss, who died in 1948, was one of the founders of the Humble Oil and Refining Co. and a chairman of the Rice Institute board.

The 23rd **venereal disease postgraduate course** will be given at Tulane Medical School of Louisiana in New Orleans from 31 Jan. through 4 Feb., cosponsored by Tulane's Division of Graduate Medicine and the U.S. Public Health Service. The course, which is accredited by the American Academy of General Practice, is designed to acquaint the practitioner with the latest developments in diagnosis, treatment, and management of venereal diseases. No tuition will be charged. Applications for admission should be made immediately to Dr. Clifford Grulee, Jr., Director of the Division of Graduate Medicine of Tulane University of Louisiana, 1430 Tulane Ave., New Orleans, La. The course is open to any physician either in civil or military practice anywhere in the United States.

A **professorship in electrical engineering** has been established at Columbia University through a grant from the General Electric Co. The professorship will be used for teaching and research in the fundamentals of generating, handling, and processing energy. John R. Dunning, dean of the School of Engineering, said that "study would be made, not only of the present status of knowledge in the . . . field, but also of applications of nuclear and solar energy. The principal objective of the professorship will be to develop courses, curricula, and fundamental research."

Fifty students enrolled for **the 5-day course in pathology of diseases of laboratory animals** held recently at the Armed Forces Institute of Pathology. Lecturers included W. H. Feldman, Mayo Foundation, on tumorous growths in dogs; A. M. Pappenheimer, Harvard University, on natural diseases of mice; F. S. Vogel, Air Force Radiobiology Laboratory, on diseases affecting chimpanzees; C. R. Cole, Ohio State University, on taxoplasmosis; and Erwin Jungherr, University of Connecticut, on parrot fever.

A program leading to the Ph.D. in the medical sciences has been established at **State University of New York College of Medicine** in Syracuse. Graduate work is offered in five fields: anatomy, biochemistry, pharmacology, physiology, and microbiology. The program is designed for those who wish to specialize in one of these preclinical subjects and should not be confused with postdoctoral education in clinical medicine for physicians. It will be supervised by a faculty committee headed by Wilfred W. Westerfeld, professor and chairman of biochemistry. Tuition has been set at $100 a semester, with a $15 activity fee for the academic year.

Available Fellowships and Awards

An expanded program for the support of research and conferences on the physiology of pregnancy was announced by Willard C. Rappleye, president of the **Josiah Macy, Jr. Foundation,** at the 25th annual meeting of the directors. In the past the foundation has given emphasis to the support of scientific investigations on the problems of psychosomatic medicine and of aging, but with enlarged resources now available, the directors have decided to give special attention to the prenatal phases of human development and the maternal adaptation to pregnancy. They will assist departments of obstetrics and gynecology to develop programs of clinical and basic research.

Six fellowships of $2000 each for graduate study in the field of aeronautical structures at the **Institute of Air Flight Structures,** sponsored by the Daniel and Florence Guggenheim Foundation at the Columbia University School of Engineering, have been announced. The fellowships for 1955–56 are open to young men who show aptitude and interest in pursu-

ing advanced teaching and research in the field of aircraft structures. A bachelor's degree is normally required, although it need not be in aeronautical engineering. The fellowships are renewable on merit. *Applications must be filed by 20 Feb.*; information may be obtained from Dr. Hans H. Bleich, Director, Institute of Air Flight Structures, School of Engineering, Columbia University, New York 27, N.Y.

A program of financial aids for students who will study for advanced degrees in the School of Industrial Management at the **Massachusetts Institute of Technology** during 1955–56 has been announced. Assistantships and fellowships, will be available to a number of students in the 2-yr course that leads to the degree of master of science in industrial management. This program is especially intended for college graduates in fields of science or engineering.

Assistantships, with a stipend of $1640 for each academic year, are available to certain men with an educational background which permits them to carry a reduced course load. For these assistants the tuition is $540. Fellowships to enable a number of students of unusual ability to attend the school are available each year. In general, these fellowships provide full tuition as a minimum and range upward to $3000 for married men or $2300 for those unmarried.

In both cases, applications should if possible be filed before 1 Mar. Further information may be obtained from the Chairman of the Graduate Committee at the School of Industrial Management, Massachusetts Institute of Technology, Cambridge 39, Mass.

The board of trustees of the **Alumni Fund of Michigan State College** offers five predoctoral fellowships ranging in value from $1000 to $1400 tenable in any subject at Michigan State College for the year 1955–56. With each fellowship a waiver of course and tuition fees is granted. Only U.S. students are eligible.

The Alumni Fund also offers one $3000, 10-mo postdoctoral fellowship, open to U.S. applicants. This fellowship is available for research in any subject for which Michigan State College has appropriate facilities. It carries with it the same housing privileges as are accorded to faculty members. Inquiries should be addressed to the Dean of the School of Graduate Studies, Michigan State College, East Lansing, Mich. *Completed applications must be received before 1 Mar. 1955.*

The Geophysical Laboratory of the Carnegie Institution of Washington and the geology department of the Johns Hopkins University are cooperating in the award of two 2-yr predoctoral fellowships in **petrology and geochemistry.** Applicants for the awards must have completed a year of graduate work in the geologic sciences and must be proficient in physical chemistry.

During the first year the fellows spend most of their time at the university completing courses and other requirements for the doctorate. The second year is devoted to research at the Geophysical Laboratory leading toward a dissertation. Stipend is $2400 the first year and $2800 the second. Application for a fellowship, supported by transcripts and recommendations, *should be sent by 1 Mar.* to Prof. Ernst Cloos, Chairman, Geology Department, Johns Hopkins University, Baltimore 18, Md.

Radcliffe College invites applications for the $3000 Helen Putnam fellowship for advanced research in any field related to human genetics or mental health—including psychology, child development, and other fields of social science. This postdoctoral resident fellowship for women permits use of research facilities at Harvard University. For information communicate with the Secretary of the Graduate School, Radcliffe College, Cambridge 38, Mass. Completed forms should be returned *by 1 Apr.*

Research proposals directed to the Division of Biological and Medical Sciences of the **National Science Foundation** will be received at any time. The proposals on research projects to begin during the first half of the academic year 1955–56 will be reviewed during March. These proposals should reach the foundation *prior to 15 Feb.*

Grants and Fellowships Awarded

The following **AAAS research grants** have been awarded:

Oregon Academy of Science to Ludlow Corbin, Portland. Effects of hormones such as estrone, estradiol, testosterone, and progesterone on the cellular division of the green alga *Chlorella.*

Georgia Academy of Science to Netta E. Gray, Agnes Scott College, Decatur. Morphologic and taxonomic studies of the tree genus *Podocarpus.*

British Columbia Academy of Science to Charles R. Harris, University of British Columbia. Bioassay of insecticides for residual contact toxicity.

Arkansas Academy of Science to George G. Iggers, Philander Smith College, Little Rock. Research on the idea of progress in recent philosophy of history.

Arkansas Academy of Science to Charles G. Hamilton, College of the Ozarks, Clarksville. Research on legislation during the progressive period in state legislatures.

Announcement has been made of new research grants recently awarded by the Surgeon General of the U.S. Public Health Service upon the recommendation of the National Advisory Mental Health Council at its November meeting. Fifteen new grants were awarded totaling $204,664. This list does not include grants awarded to investigators for the continuation of projects previously supported by the **National Institute of Mental Health.** Forty-nine such grants, totaling $585,979, were also awarded at the November meeting.

Yale University. F. A. Beach. Psychophysiology of reproductive behavior, $14,248, 5 yr.

Council Child Development Center. E. K. Beller. Fear, aggression and dependency in childhood $15,766, 1 yr.

Harvard University. G. Caplan. Evaluation of a mental health program for student nurses, $14,430, 1 yr.

University of California. H. S. Coffey. Relation of group tension to interpersonal role, $6304, 1 yr.

American Psychological Association. J. E. Anderson. Research conference on psychological aspects of aging, $9990, 1 yr.

University of Wyoming. R. H. Denniston. Relation of hormonal factors to behavior, $4175, 3 yr.

University of Chicago. N. N. Foote and D. Riesman. Functions of play in developing adulthood, $21,600, 3 yr.

Harvard University. D. H. Funkenstein. Interpersonal perception in schizophrenia, $9654, 3 yr.

Yale University. D. E. Hunt. Effect of need for approval on children's behavior, $4390, 2 yr.

New York University. M. Jahoda. Psychology of role acceptance in women, $10,751, 1 yr.

Washington University. F. H. Kanfer. Studies in verbal behavior, $7208, 3 yr.

George Washington University. W. Overholser. Effect of psychoanalysis on therapist's techniques, $15,637, 3 yr.

Mount Zion Hospital. S. Reichard. Psychogenic factors in schizophrenia and the neuroses, $8400, 1 yr.

Harvard University. B. F. Skinner and H. C. Solomon. Experimental analysis of psychotic behavior, $30,000, 2 yr.

Harvard University. J. P. Spiegel and F. R. Kluckhohn. Influence of family and culture on mental health, $32,011, 2 yr.

The November allocations of the **Damon Runyon Memorial Fund** for Cancer Research are as follows:

University of Helsinki, Institute of Forensic Medicine. Unto Uotila, $3000.

University of Helsinki, Institute of Forensic Medicine. Harald Teir. Study of malignant growths, $5000.

University of Helsinki, Institute of Forensic Medicine. Kai Setala, $7000.

Pasteur Institute, Paris. Raymond Laterjet, $5000.

Hopital des Enfants Malades, Paris. Georges Schapira, $3500.

Columbia University. To support five projects in cancer research, $60,920.

Institute of Industrial Medicine, New York University–Bellevue Medical Center. Norton Nelson, $10,000.

Mount Zion Hospital, San Francisco. B. L. Freedlander. Chemotherapy of experimental mouse tumors, $7000.

Children's Cancer Research Foundation, Boston, Mass. George Yerganian, $5700.

Boston University. Paul Fulton and Maurice H. Shulman, $5000.

Fellowships

Jose Riera Vinas, New England Center Hospital, Boston. Studies of white cell antibodies.

Pier Luigi Melanotte, University of Utah, Salt Lake City. Experimental research in bone growth and in bone tissue mineral metabolism.

In the Laboratories

Ab Kabi, a Swedish pharmaceutical company, and the **Pfizer Corp.** have concluded an agreement that will permit the production of Terramycin and Tetracyn in Sweden. Some 30 other pharmaceutical preparations will also be launched on the Swedish market. Ab Kabi has made penicillin for many years and its output of streptomycin is seven times larger than Swedish consumption.

A $2,100,000 electronic computing machine, said to be the biggest in Britain, has been installed at the **Royal Aircraft Establishment** in Farnborough, England. The unit covers 6000 ft² of floor space, contains 8000 electron tubes, and is maintained at constant temperature by the circulation of air at a rate of 30,000 ft³/min. The machine is expected to save both time and money in the development of guided weapons and high-speed aircraft.

The new **André Meyer Department of Physics in Mount Sinai Hospital,** New York, has been dedicated. The new physics department is the gift of Mr. Meyer, a hospital trustee. In addition to its own full-time staff of 15, the department will house investigative activities of some 70 physicians and scientists from collaborating services taking part in a research program that last year spent $900,000. The department stems from a one-man, one-room laboratory started in 1938 for work on biophysics and on the standardization of scientific instruments.

In November the **Fisher Scientific Co.** opened a new plant at 1458 N. Lamon Ave., Chicago 51, Ill. In the technical service and demonstration laboratories of the new facility visitors at the opening saw the latest in electronic instrumentation and the 37,000 ft² warehouse, so completely integrated by pneumatic and conveyor systems that 10 men can handle the stock of more than 16,123 different items of apparatus and several thousand different reagent chemicals. As special features the company transferred from Pittsburgh its "Pasteur Memorial U.S.A.," the largest collection of Pasteur portraits and manuscripts and original letters in this country, and the 18-ton Fisher Mobilab, a complete laboratory-on-wheels.

The National Association for Mental Health has awarded **Smith, Kline, and French Laboratories** and the **American Medical Association** citations for their television production "Search for Sanity" which was presented on the *March of Medicine* program on 31 Oct. It marked the first network use of live television cameras in a hospital for the mentally ill. The citation commends the program for its "outstanding contribution to public understanding of the problem of mental illness."

Construction of a large electronics laboratory for engineering and research, to cost nearly $1,500,000, was begun by the **Raytheon Manufacturing Co.** on 29 Nov. on a 73-acre site in Wayland, Mass. Raytheon has more than 1500 professional engineers among its approximately 18,000 employees, and the new building with its 150,000 ft² of floor area will provide office and laboratory space for the largest single group of engineers within the company.

Hillside Hospital, Glen Oaks, N.Y., has established a research service devoted to the study of psychologic, neurophysiologic, and biochemical aspects of mental illness. Funds for the service have been appropriated by the board of directors, supplementing two grants by the U.S. Public Health Service, and one by the Dazian Foundation for Medical Research. Maximilian Fink, former supervising psychiatrist at the hospital, has been appointed director of research.

Erratum: In the issue of 29 Oct. 1954 the name of the third author of "Effect of 2,4-D on respiration and on destruction of IAA in oat and sunflower tissues," page 710, was incorrectly spelled. It should be Dawson C. Deese (not Desse).

Book Reviews

Atomic and Free Radical Reactions. vols. I and II. ACS Monograph Series. E. W. R. Steacie. Reinhold, New York, ed. 2, 1954. x + 901 pp. Illus. $28 the set.

This work, a revision and an enlargement of the one published in 1946, summarizes most of the known information about the gas-phase reactions of atoms and free radicals with organic molecules. The first chapter is a 12-page introduction to the concepts of chemical kinetics, principally those of particular application to free-radical reactions. The 58-page chapter on experimental methods is a systematic discussion of the methods for producing and measuring free radicals in the gas phase, and it is not a laboratory manual. The next chapter (28 pp.) is a critical discussion of the methods for determining bond dissociation energies, and it is a compilation of reasonably well-established values. The first volume ends with two chapters on the major thermal (176 pp.) and photochemical (207 pp.) reactions involving free radicals.

The second volume begins with a 24-page chapter summarizing the activation energies and frequency factors for several groups of elementary reactions, a typical group being the abstraction of H atoms by methyl radicals from a series of compounds. The bulk of this volume (278 pp.) is devoted to a systematic listing of information about the rates of 1034 elementary reactions, for example, $H + C_2H_6 \rightarrow C_2H_5 + H_2$. These are the elementary reactions, which, in combination, represent the mechanisms of most of the overall thermal and photochemical reactions discussed in the first volume. Volume II concludes with author, subject, and reaction indexes and with a bibliography of 2086 entries.

The book seems to be exhaustive and carefully done. The tenor of the discussions is cautious, and conflicting views are set out fairly. A serious fault is the price, one factor of which is the high unit cost of 3.1 ct per page compared with 2.6 ct for the average of 10 of the books advertised on the dust jacket, and with about 2.2 ct for some recent books of probably smaller general interest. It is, therefore, all the more desirable that the organization of the book minimize the total number of pages. The author's arrangement fails in this respect since, although it is a convenient one, it leads to considerable duplication. For example, the decomposition and polymerization of propylene is discussed in three pages of the section on free radicals in thermal reactions, the discussion referring to some 16 papers. In the detailed section on individual reactions, nine of these references are repeated, some with almost the same wording. Such duplication is not undesirable per se, since one reads the different sections for different purposes, but it is an expensive luxury. Another luxury is the format of much of the second volume, where each reaction is set off by itself even if the information is only a cross-reference, and where the information is given *in extenso*. One would think that a tabular presentation could have been devised that would serve for all except a few of the most-studied reactions.

With the accelerating growth of chemical research, it is more than ever necessary to have compilations such as this one that offer the chemist a critical and reasonably complete survey of the data of a particular field. Kineticists will be grateful to Steacie for filling so well the need in this field.

ELLISON H. TAYLOR
Chemistry Division, Oak Ridge National Laboratory

The Development of Medical Bibliography. Estelle Brodman. Medical Library Association, 1954 (Order from: Archives Curator, Medical & Chirurgical Faculty of State of Maryland, Baltimore 1). ix + 226 pp. Illus. + plates. $5.

Foundations of modern librarianship were laid in the last quarter of the 19th century when the expanding literature made the "keepers of books" realize that a more systematic arrangement of books was necessary. Thus was developed that phase of librarianship which is commonly referred to as library economy. So important were these basic techniques considered that for many years they overshadowed in emphasis the necessity for scholarship so essential to true librarianship. As librarianship grew, the need of specialization within the profession began to develop. More than 50 years ago a small group of medical librarians and physicians assembled in Philadelphia to organize a professional association for furthering the aims of medical librarianship. This group has continued to promote standards for libraries and librarians. Progress has been made in establishing a profession of medical librarianship, but only recently has attention been turned toward the fundamental basis of any profession and that is scholarship. Brodman's monograph is a landmark in medical librarianship because it demonstrates that medical bibliography is a scholarly pursuit and that scholarly investigations can be undertaken within the field of medical bibliography.

Brodman's purpose, as stated in the preface, was to write a history of the development of medical bibliography. This history was to be interpretive, not simply a chronicle. Her approach to the problem was both logical and thorough. She examined all known bibliographies of medicine that were available, interpreting their place in the history of medical bibliography. She presented the problem of indexing of each era and the solution of this problem by the bibliographer. Each bibliography's contribution to the art of bibliography was then reviewed. Its failings were pointed out and discussed so that one has a clear picture of the place of this particular bibliography in history. It is the

third chapter, "The golden age of individual bibliographers," that is so interesting to the bibliographer of today. For here are described the various problems confronting the 19th century bibliographer who was trying to index a rapidly expanding literature. The importance of this period is that we are today mainly following the same principles of indexing and we are encountering the same difficulties that Plocquet saw and tried to overcome. In conclusion, the author points out that the problems which beset medical bibliography in the past are the same today, only the quantity has changed, not the quality. Notwithstanding the development of mechanical aids, it has not been possible to work out methods for solving the index requirements of modern medical science. The individual bibliographer is still the key to indexing.

The work closes with a list of references and medical bibliographies published since 1500. A well organized author index to bibliography and a general index concludes the monograph. In very readable style and well documented, it gives an excellent comprehensive picture of medical bibliography, both past and present, the difficulties encountered, how they were solved, and the meaning this has for those who are trying to solve the problem of medical indexing today.

WILLIAM DOSITE POSTELL
Louisiana State University School of Medicine

Physics and Applications of Secondary Electron Emission. H. Bruining. McGraw-Hill, New York; Pergamon Press, London, 1954. xii + 178 pp. Illus. $5.

This is a survey based in large part on 393 papers related to the emission of electrons from different kinds of substances in the solid state, from the discovery of the phenomenon in 1902 through 1952. The first seven of the 10 chapters are on physical aspects and the last three are concerned with application aspects. These three chapters are on electron multiplication, disturbing effects that arise from secondary emission, and desirable effects produced in electronic tubes of various kinds. It is evident that a complete theory of the mechanism of secondary electron emission does not yet exist, and that the author has surveyed the various approaches that have been made.

The monograph fulfills its primary purpose quite adequately. It falls a little short of being an elementary textbook since part of what is said in chapter 1 assumes knowledge of the terminology and ideology of later chapters, and in a few spots the sentences lack the details desirable in a textbook. As a reference for the researcher and a guide for the advanced seminar student, the book is excellent.

The chronological list of 393 references appears to be exhaustively complete. The references published during the first 30 years after discovery of secondary electron emission are almost all American or German, about equally divided. The first Japanese reference is dated 1933. It is interesting to note that the Russian references begin abruptly with six in 1936, marking the start of a period of intensive activity that yielded 40 papers in 6 years. These references drop as suddenly to a low rate of occurrence, and none are listed after 1947.

SHERWOOD GITHENS, JR.
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Durham, North Carolina

The Infrared Spectra of Complex Molecules. L. J. Bellamy, Methuen, London; Wiley, New York, 1954. xvii + 323 pp. Illus. $7.

In recent years infrared spectroscopy has assumed an increasingly important role in the industrial research laboratory and has taken its place along with other physical methods of analysis, such as optical spectroscopy, x-ray diffraction, and mass spectroscopy. It has been adequately demonstrated that, as a method for the recognition of structural groups in compounds, for the recognition of compounds in mixtures, and in quantitative analysis, it is applicable to classes of problems not easily, if at all, handled by other methods. So widespread are the applications of infrared spectroscopy to allied fields that many investigators with various backgrounds are finding it advantageous to employ infrared methods and to learn the basic methods of interpretation of the spectra obtained. With the exception of the general and elementary discussion by Barnes, Gore, Liddel, and V. Z. Williams, and the more recent and fuller account by Randall, Fowler, Fuson, and Dangl, there has been no single work to which the investigator could go for information on this subject. To be an effective worker in this field demands a wide knowledge of and experience with the absorptions by a great many compounds containing the same or similar structures. Since the literature is scattered over many journals and years, this knowledge is difficult to come by. It is, therefore, my opinion that there has long been a need for a book such as this one, and that present investigators and students alike owe a debt of gratitude to Bellamy for having correlated and reviewed critically this great mass of empirical data.

Bellamy's treatment of this complicated subject is orderly and clear. The knowledge that is necessary in structure recognition and correlation is, to a large extent, empirical in nature. Bellamy has made a critical survey of the existing data on which such correlations are based, and he has drawn conclusions that will be of aid to new and old workers alike in pursuing independent recognition researches. He has divided the mass of information into four parts consisting mainly of the following topics: part I, C—O and C—H linkages; part II, C—O and O—H linkages; part III, C—N and N—H linkages; and part IV, vibrations involving other elements or elements of inorganic origin. Each part is then further broken

down into chapters covering specific groups. In these chapters he discusses in considerable detail typical regions of absorption of the various groups and the way in which interactions between groups affect the absorption regions. In the book he follows what is coming to be standard practice among infrared spectroscopists—using wave numbers for band positions rather than wavelength in microns. The book contains a table of reciprocals for the convenience of those who prefer to think in terms of wavelength. Each chapter begins with a convenient outline of the correlations subsequently discussed and ends with a bibliography of the specific papers referred to so that the reader may go to the original source if he prefers. The bibliography is complete enough to permit the location of every significant contribution. At the beginning of the book there is a set of correlation charts, extending from 3750 to 650 cm^{-1}, that are more complete than any this writer has seen published heretofore. The book is quite well illustrated at the end of each main part with examples of prism spectra, although it would have been worthwhile to make reference to these figures at appropriate places in the text.

Both the persons beginning to acquire knowledge in this field, as well as persons already versed in it, will find this book indispensable.

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Weather Modification: Past, Present and Future. Kenneth M. Arenberg *et al.* Weather Modification Group, Wollaston, Mass., 1954. 50 pp. Paper, $3.

Expanding interest in weather modification is manifest in this pamphlet report which can best be described as a digest summary of current literature coupled with the conclusions of the six authors.

A short discussion of the history of weather modification precedes a summary of the physical basis of modern cloud-seeding attempts and a brief outline of the Bergeron-Findeisen ice-crystal hypothesis. The process of rain formation without the involvement of ice was apparently unknown to the authors. The chapter on verification, highly colored by claims of various commercial cloud seeders, cannot be accepted as more than a selection of some of the current arguments.

The role of government and commercial enterprise is outlined, including a list of some government-sponsored projects and pertinent quotations from their reports. A fairly concise notion of the operation of a typical rain-making firm is given.

The best written and least controversial chapters deal with the potential application of weather modification and government regulations thereof. The authors feel that detailed federal regulation is unnecessary and that some of the cited Congressional bills are actually undesirable. They suggest that the government require cloud seeders to be licensed, require full reports of weather-modification activities, and assume the liability of private contractors on government-sponsored projects.

The authors have successfully combed a difficult and controversial subject to prepare this acceptable report. However, it has several features that detract from its value. After explaining the "ice-crystal" precipitation hypothesis and showing that Dry Ice and silver-iodide seeding act in supplying missing ice nuclei to supercooled clouds, the authors ignore the problem of the frequency of clouds in need of such nuclei. The fact that precipitation often forms at temperatures warmer than freezing is overlooked. Much of the information concerning research projects at universities and in government is marginally factual. One gets the impression that the authors believe the best evidence for the effectiveness of cloud seeding is the fact that many persons are willing to pay for such services. Although this may be a perfectly valid test, many readers will prefer a conclusion based on more scientific evidence.

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Synthetic Methods of Organic Chemistry. vol. 8. An annual survey. W. Theilheimer. S. Karger, Basel; Interscience, New York, 1954. xv + 508 pp. $18.90.

This work is an attempt to make new or improved synthetic methods readily available to the organic chemist. The series began with the literature appearing in 1942, and the present volume is drawn mostly from papers published from 1951 to 1953. The arrangement of the methods is based on an arbitrary system that takes into consideration the chemical bonds formed, the type of reaction, and the chemical bonds destroyed. For example, HC$\diagdown\!\|\!\diagup$OC represents the hydrogenation of a carbonyl group, the symbol between the chemical symbols indicating that the process occurs by addition. Although such a system easily builds up resistance in many chemists, it not only offers a basis for classification, but, more important, it facilitates thoroughness since the reactions of a functional group are found under the group and not, as is so often the case, under the numerous compounds containing the group. It should be added that the system can be avoided by using the extensive index (for vols. 6, 7, and 8) of more than 100 pages that list reactions by name, general topics, starting materials, and end products.

It is my opinion that this survey fills a definite need. The limited number of syntheses that are checked in the present volume appear to be properly recorded and give essential facts, such as the number and nature of the reaction steps, the yield, and the important literature. In spite of the many aids available to the organic chemist, this one offers a particular appeal, largely because the syntheses described are so recent. The author promises greater promptness in the volumes yet to come.

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Theoretical Physics. Mechanics of particles, rigid and elastic bodies, fluids, and heat flow. F. Woodbridge Constant. Addison-Wesley, Cambridge, 1954. xiv + 281 pp. Illus. $6.50.

According to the author's preface,

> This book is intended primarily as a text for a senior-graduate course in physics. In many of our colleges the elementary and intermediate courses in physics are followed by an introductory course in theoretical physics, open to eligible juniors, seniors, and beginning graduate students. Many students, as well as professors, have agreed that such a course is of great value. It not only serves as a bridge between the more elementary, factual undergraduate courses and the more advanced, analytical ones of graduate school, but it also provides a valuable review of physics and mathematics at a higher level. The aim of this book is to help achieve such a goal.

The book is divided into three parts: vector analysis, mechanics, and heat flow.

The section on vector analysis (44 pp.) is divided into three chapters dealing with the algebra of vectors, the calculus of vectors, and dyadics. A vector is defined as a quantity having "both a magnitude and a direction." The addition law is taken as experimental, and no mention is made of transformation laws in the *definition*, although orthogonal transformations are discussed later. The vector operator ∇ is *defined* in terms of rectangular coordinates; and the gradient, divergence and curl are then defined in terms of ∇. This makes transformation to other coordinate systems quite cumbersome, but more important it obscures the physical significance of divergence and curl. In dealing with curvilinear coordinates, the author does a very careful job of discussing the derivatives of the unit vectors, but then he fails to point out the pitfalls of applying ∇^2 to a *vector* function if the components of the vector are expressed in other than rectangular Cartesian coordinates.

Part II consists of 11 chapters devoted to mechanics, elasticity and fluid dynamics. Kinematics, other than for rectangular Cartesian coordinates, is restricted to two dimensions, and the treatment is quite satisfactory. With the background chapters on vectors in three dimensions, it would have been very easy to extend this treatment to at least spherical coordinates. There is a good elementary treatment of motion relative to moving axes. Gravitation is treated in five pages, and gets no further than one might expect in an elementary course. There follow chapters on particle motion and motion of a system of particles. There is ample treatment of rigid body motion, too large a fraction of which seems to be devoted to motion about a fixed direction, and a chapter on advanced dynamics in which Lagrange's equations are obtained as well as the Hamiltonian equations. The principle of least (stationary?) action is discussed in some detail. There is a concise chapter on the elements of elasticity, followed by one on elastic waves and sound, and a short chapter on viscous mediums. The section concludes with a chapter on general principles of fluid dynamics; more could have been done with the chapter on viscous mediums had it followed this one, which contains a clear concise treatment of the subject.

Part III, a single chapter of 12 pages on heat flow, is the least satisfactory. Just as things begin to get interesting, we come to the end. The problems are mostly elementary, and do not even do justice to the chapter material, some of which is unnecessarily complicated. For example, it is stated that two integrations by parts are necessary in order to evaluate the integral of the product of two sine functions, whereas, in fact, none are necessary.

The degree of difficulty of the material presented in the book is far from uniform, and this is not necessarily a criticism. However, quite a bit of the material should be familiar from a first course in physics. Also, one might wish that the illustrative examples were more thought provoking. The book could serve a useful purpose as a second course in physics after a good quantitative first course, or for self-study by the more ambitious student. In a new edition, more attention might be given to detail and completeness, which could easily be done by omitting some of the more elementary portions.

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Biological Effects of External Radiation. Henry A. Blair, Ed. McGraw-Hill, New York—London, 1954. xviii + 508 pp. Illus. $7.

This volume summarizes the major part of the studies made during the World War II period on the biological effects of x-radiation at the University of Rochester, and on the effects of chronic neutron irradiation at the Biochemical Foundation, Newark, Delaware. There are three parts to the book: part 1 deals with the effects of single doses of whole-body x-radiation (8 chapters, approximately 200 pp.); part 2 is concerned with chronic x-radiation (7 chapters, approximately 200 pp.); part 3 deals with the effects of fractionated doses of fast neutrons (2 chapters, approximately 100 pp.). There is an 8-page subject index.

In the first part single doses of x-rays are reported with regard to their effects on the mortality of rats, dogs, and monkeys (Boche and Bishop), pathological changes in rats (Metcalf, Blandau, and Barnett), peripheral blood in rats, dogs, and monkeys (Ingram and Mason), callicrein in dogs and rats (Fink), cross-circulation experiments with cats (Lawrence and Valentine), finger-ridge changes in monkeys (Harvey), mutation rate in fruit flies (Spencer and Stern), and their effectiveness in comparison with beta radiation in rabbits (Bishop).

The second part discusses the effects of chronic x- (or gamma) irradiation on rats, dogs, monkeys, and rabbits (Dowdy, Boche, and Bishop), their growth, survival (Boche), and peripheral blood (Ingram and

Mason), on pathological changes in rats (Metcalf and Inda), on blood chemistry in dogs (Fink), on finger-ridge detail in humans (Harvey), and on mutations in fruit flies (Caspari and Stern, Uphoff and Stern).

The last part deals with fast neutron irradiation procedure (McDonald) and the clinical, pathological, and hematological effects of chronic irradiation of rats, rabbits, and dogs with neutrons (Ely, Ross, Metcalf, Inda, Barnett, and Casarett).

All chapters are based either on MDDC or UR reports, some prepared as early as 1946 and some published in journals in the period 1947–49. There are no integrative chapters because

Delays in preparation and publication permitting the appearance of other reports allowed it to become evident that only more general integration would be of real value and that this would require a separate work. Consequently, each chapter refers separately to other investigations according to the results available when it was written.

For these reasons this volume will be more valuable in the institution library than on the private bookshelf.

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New Books

Exploring Mars. Robert S. Richardson. McGraw-Hill, New York–London, 1954. 261 pp. $4.

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A Dictionary of Electronic Terms. Concise definitions of words used in radio, television & electronics. Gordon R. Partridge, Ed. Allied Radio Corp., Chicago 80, 1954. 72 pp. 25¢.

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Tratamiento del Hexafluoruro de Uranio Gaseoso por Medio del Modelo Molecular de Potencia Inversa. Serie fisica, vol. 1, No. 3. Juan A. McMillan. Comision Nacional de la Energia Atomica, Buenos Aires, 1954. 6 pp.

Technical Papers

Effects of Cell Division Inhibition on Phosphorus Metabolism of *Escherichia coli*

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Apropos a recent article by Webb (*1*) concerning the phosphorus and nitrogen metabolism of filamentous forms of bacteria, which were induced by controlled magnesium deficiencies, we are reporting the results (*2*) obtained from a series of experiments initiated a few years ago to elucidate the mechanisms of cell division. An effort was made to correlate cell division inhibition in *Escherichia coli* with possible changes in the phosphorus compounds of the bacterium.

Filamentous forms of *E. coli* can be induced, under conditions that inhibit cell division but not growth, by treatment with α-, x-, and γ-radiations as well as by treatment with certain organic compounds (*3–5*).

Cultures of *E. coli* strain B were grown as previously described (*4, 5*). Cells were treated during the logarithmic stages of growth and division with an appropriate dose of a cell division-inhibiting agent and growth was continued for 1½ hr during which time the control cells maintained logarithmic rates of division and growth and the treated cells maintained only a logarithmic rate of growth (*5*). The treated, filamentous cells were 3 to 4 times the length of the control cells. Such treated cultures are strikingly uniform in appearance in that less than 5 percent of the cells are as small as the controls (*6*). At the end of the growth period cells were harvested and subjected to chemical analysis.

Samples weighing approximately 600 mg were fractionated by the methods of Morse and Carter (*7*). and Schmidt and Thannhauser (*8*). All phosphorus in the desoxyribosenucleic acid (DNA) fraction could be accounted for as DNA phosphorus by comparisons with a purified DNA standard of the 260 mμ absorption E_p (*9*) as well as by the colorimetric methods of Dische (*10*) and Stumpf (*11*). Similarly, all the phosphorus of the ribosenucleic acid (RNA) fraction could be attributed to RNA phosphorus by the 260 mμ absorption E_p and by its ribose content by colorimetric analyses (*12*) and comparisons with ribose and purified RNA.

Table 1 summarizes the results obtained when 5-diazouracil is used as the cell division inhibitor. With the exceptions noted for α-radiation and acriflavine, the results obtained for 5-diazouracil, x-radiation, and triethylenemelamine followed the same general pattern (*2*). With α-radiation a small but statistically significant decrease was observed in the stable organic phosphorus fraction (10 to 20 percent). However, this may be a radiation effect peculiar to the α-radiation (*15*) and may be in no way a result of cell division inhibition. Such an effect may be related to the adenosine triphosphate leakage found by Billen *et al.* (*16*) when *E. coli* was subjected to lethal doses of x-rays. Treatment with acriflavine caused a statistically significant decrease in the DNA phosphorus fraction. However, the 95 percent confidence interval indicates rather substantial experimental variation which makes the data for this fraction suspect.

Apart from the aforementioned effects, all other phosphorus fractions of the filamentous *E. coli* showed no change in intracellular phosphorus when compared with the normal cells. These results are similar to those reported by Webb (*1*) for the filamentous bacteria formed in a magnesium deficient medium in that no changes in intracellular phosphorus were found in their experiments.

The fact that for any fraction the values for the controls and experimentals are identical (total culture masses for controls and experimentals are also equal) within experimental error might indicate, as a working hypothesis, that the filamentous forms are made up of the same number of "units" as are found in the controls. Microscopic observations of stained cells have shown that the filamentous cells are multinucleated; however septa have never been observed in filamentous cells (*17*).

It is interesting to note that a specific biological function, namely cell division, may be inhibited by a variety of techniques such as subjecting them to a deficiency of substances required for growth (Mg^{++}),

Table 1. Effect of 5-diazouracil (concentration 0.3 μg/ml) on phosphorus fractions in *E. coli*.

Fractions*	Control†	Experimental†	Deviation	95% Confidence interval of the true mean‡
Ortho-P	0.158	0.164	− 0.006	− 0.013 → 0.001
Labile-P	.033	.033	.000	− .003 → .003
Stable-P	.157	.153	.004	− .009 → .017
Lipid-P	.129	.144	− .014	− .032 → .004
RNA-P	1.30	1.35	− .05	− .013 → .03
DNA-P	0.307	0.269	.038	− .007 → .083

* Phosphorus was determined by a colorimetric method (*13*); ortho-P by direct estimation of the acid extract; labile-P = [P (10 min at 100°C in 1*N* HCl)] − [ortho-P]; stable-P = [total phosphorus of acid extract] − [P (10 min)]; other fractions as (total − P).

† In mg of phosphorus per 100 mg of dry weight.

‡ The results of five experiments were statistically analysed (*14*) by computing the experimental error from the variation in the differences between pairs of runs made on the same day, and the 95 percent confidence interval was then computed for the true mean difference between controls and experimentals.

to radiation, or to certain organic compounds. In all probability there is more than one mechanism involved when the inhibition is produced by these several means, even though the end result is the same, that is, cell division is inhibited and, where phosphorus analyses have been made, no changes in phosphorus metabolism have been noted. Such reasoning, however, does not preclude the possibility that *ultimately* a single sensitive locus might be affected in order to form filamentous cells.

It is clear from the data available here and in the literature (*1*) that interference with the synthesis of DNA or of RNA is not the causative mechanism responsible for filament formation. It is pertinent to make this point clear because the results of earlier investigators leave the impression that nucleic acid inhibition is involved in cell division inhibition. This seems true only when growth and division are inhibited and does not hold under conditions where only division inhibition occurs.

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4 October 1954.

Humidity Responsive Organics

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The electric resistance of strips cut from thin sheets of gelatin, agar, pectin, polyvinyl alcohol, and so forth, depends on the relative humidity of the surrounding atmosphere in the way shown in Fig. 1.

Strips used in obtaining data were made by cutting rectangles 2 by 0.5 cm from sheets 0.075 mm thick. Each end of a rectangle was slid between adjacent turns of a spiral of thin tinned copper wire that served as an electrode. To improve electric contact and hold the wires mechanically to the strip at each end, the wire-to-strip junction was painted on both sides with conducting paint (*1*). The sensitive region of the assembly was then 1 by 0.5 cm on each of its two sides. The charge flowed in the long direction.

Sheets were made by mixing a quantity of solid material with water, heating it in a double boiler until the liquid was clear, pouring it on a level paraffin-coated glass plate, and allowing it to dry at room temperature. All resistances were measured at 27°C by charging a condenser through the prepared strip, using a potential difference of 255 v, and measuring the time required to charge the condenser to 180 v (*2*). The circuit was calibrated with Victoreen resistors (*3*) and frequently tested to prove that leakage resistance across the supports was negligible. All materials tested have negative temperature coefficients of resistance. The atmospheres at various values of relative humidity were obtained by using saturated solutions of inorganic salts (*4*).

The graph of a unit made from a half-and-half mixture (by dry weight) of different materials is about halfway between those of the two components, as is shown in Fig. 1 for gelatin and pectin. Figure 1 also shows that a relatively small quantity of glycerol added to gelatin tends to move its graph to the left.

If a unit that has reached equilibrium in a chamber having a certain constant humidity is suddenly changed to one having a different humidity, a new state of equilibrium will be attained in about the same time that would be required for a hair hygrometer.

In view of the chemical complexity of most of the materials and the difficulty of making units having the same dimensions, reproducibility from unit to unit is not great.

Units made from various materials have been used successfully for the control of humidity of chambers

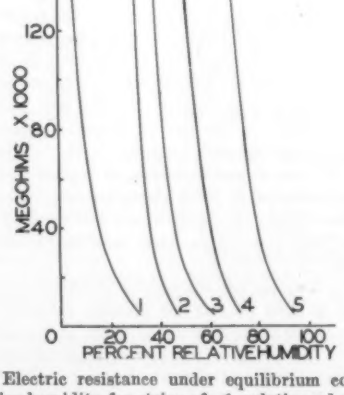

Fig. 1. Electric resistance under equilibrium conditions *vs.* relative humidity for strips of: *1*, gelatin and glycerol; *2*, pectin; *3*, agar; *4*, pectin and gelatin; and *5*, gelatin.

in connection with a suitable electronic circuit. Delay in coming to equilibrium is not a disadvantage for control purposes because the control circuit tends immediately to correct humidity, leaving the unit always in a region of substantially constant humidity, and also because materials may be selected from Fig. 1 so that operation occurs where the curve is so steep that the unit responds with almost triggerlike action.

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4 October 1954.

Estimation of Basicity with a Novel Thermochromic Indicator

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In the course of extending the analytic utility of iron-III compounds many striking cases of solvochromism (*1*) and thermochromism have been discovered (*2*). These phenomena have been observed particularly with the iron-III chelates of hydroxamic acids, amidoximes, and a variety of orthosubstituted phenols. For example, solutions of ferric chloride, propyl gallate, and *m*-chloroaniline may be blue, green, or yellow at room temperature, depending on the solvent.

Water, hydrocarbons and their halogen derivatives, alcohols, mercaptans, carboxylic acids, and diaryl ethers yield blue solutions; some arylalkyl ethers, acetals, and orthoesters give green solutions; aliphatic and heterocyclic ethers, esters, aldehydes, ketones, nitriles, and nitro compounds yield yellow solutions (*3*). These solutions change color reversibly with temperature in the order blue $\rightleftharpoons$ green $\rightleftharpoons$ yellow. Substitution of progressively weaker or stronger bases for *m*-chloroaniline in a given solvent produces the same chromic order as increasing or decreasing the temperature respectively. These findings may be summarized by the equation

$$\underset{\text{(yellow)}}{\text{Propyl gallate + ferric chloride}} + \text{base} \underset{\text{increasing temperature}}{\overset{\text{increasing strength of base; increasing "basicity" of solvent}}{\rightleftharpoons}} \underset{\text{(blue)}}{\text{chelate}} + (\text{H base})^{+}$$

For the purpose of indicating the function of the base, the products are shown as separate entities. In reality they are probably linked as an ion pair or a hydrogen bonded complex in the low dielectric mediums in which this system was studied.

A quantitative study of this observed interdependence of temperature, solvent, and strength of added base on the extent of chelate formation led to the finding that the classical ionization constant of aromatic amines could be estimated to ± 0.4 pK_b unit at worst. It was observed that the temperature at which the blue color of the chelate just reappeared on allowing a momentarily boiled solution to cool slowly in the atmosphere could be reproduced to ± 2°C. Using bromobenzene as a solvent, we studied the critical thermochromic temperature as a function of the base strength of aromatic amines. A plot of these temperatures against the aqueous pK_b values resulted in an approximately linear relationship. The analytic expression for the straight line passed among the points is given by the equation $pK_b = 13.1 - (T/30)$. Table 1 gives the experimental data and the deviations of the measured values from the calculated pK_b values.

Table 1. Basicity constants of aromatic amines from thermochromic measurements.

Aromatic amine	Critical thermochromic temp. (°C)	Calculated pK_b	Literature pK_b*	ΔpK_b
Diphenylamine	−12	13.5	13.1	0.4
2,5-Dichloraniline	5	12.9		
o-Bromoaniline	26	12.2		
o-Chloroaniline	34	12.0	12.0	.0
m-Bromoaniline	79	10.5		
m-Chloroaniline	81	10.4	10.4	.0
Dimethylaniline	98	9.8	9.6	.2
p-Chloroaniline	102	9.7	9.8	.1
p-Bromoaniline	102	9.7	10.0	.3
p-Toluidine	105	9.6	9.7	.1
m-Toluidine	105	9.6	9.3	.3
Aniline	105	9.6	9.3	.3
o-Toluidine	110	9.4	9.5	.1
Pyridine†	110	9.4	8.6	.8
6-Methyl quinoline	113	9.3		

* These pK_b values were calculated from tables of dissociation constants in the *Handbook of Physics and Chemistry* (ed. 34), p. 1560 and in various works on organic chemistry.

† The temperature value for pyridine is relatively lower than the others because of an appreciable loss through evaporation during measurement. This was the only base tried whose boiling point was lower (by 40°C) than that of the solvent. Hence the statement in the text that this method can give pK_b values to ± 0.4 unit refers to those bases whose boiling points exceed that of the solvent.

The measurements were carried out in the following manner. To 7.5 ml of bromobenzene were added 5 drops (0.05 ml/drop) of ferric chloride-propyl gallate indicator, and 5 drops or 150–170 mg of base in a test tube (o.d., 29 mm). The indicator solution consists of 2 g anhydrous ferric chloride and 4 g propyl gallate dissolved in 100 ml glacial acetic acid and 1 ml

acetyl chloride (*4*). A thermometer was placed in the tube and the solution was heated to boiling. The resulting yellow solution was then allowed to cool in the atmosphere while stirring gently, and the temperature noted at the moment when the solution turned blue.

The critical thermochromic temperature was unaffected by considerable variation in base concentration. Such a large excess is present relative to the indicator components that its concentration remains practically constant regardless of the extent of the chelate formation. The mole ratios of ferric chloride : propyl gallate : various bases were 1 : 1.5 : 28 to 58.

The aliphatic amines and 2-aminopyridine were strong enough bases to keep the bromobenzene solution of the indicator blue at its boiling point. Attempts to use solvents possessing higher boiling points and/or greater intrinsic acidities to extend the range to strong bases proved futile. However, in view of the wide variation in stability constants of various chelates, it should be possible to find different chelate-solvent combinations for the estimation of other ranges of basicity and acidity.

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1. A term coined to indicate change of color with solvent.
2. S. Soloway and A. Lipschitz, *Anal. Chem.* **24**, 898 (1952); S. Soloway and S. Wilen, *ibid.* **24**, 979 (1952); S. Soloway and P. Rosen, *ibid.* **25**, 595 (1953).
3. The detailed presentation of these data, their meaning, and their use as a basis for classifying organic compounds will be the subject of a future publication.
4. The utility of this indicator for the determination of water in alcohols will be described in a later paper. The determination depends on the observation that the addition of water to an alcoholic solution of this indicator causes a color change from yellow or green to blue. This change results from the fact that water functions as a base in dilute alcoholic solution.

6 October 1954.

Action of Cortisone on Disseminated Tumor Cells after Removal of the Primary Growth

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It has been reported by several workers (*1*) that repeated injections of cortisone give rise to an increased metastatic spread of a variety of transplanted and induced tumors. This finding has been disputed by Kaliss using a transplanted tumor (*2*). From the sum of evidence available it would seem clear that cortisone does have an effect in metastasis, but that it is one that may well operate only with specific tumors and not with others.

In attempting to analyze this phenomenon Pomeroy (*3*) has found that cortisone will increase the number of "takes" following an intravenous injection of a suspension of transplantable tumor cells. This would seem to indicate that cortisone exerts an action on the phase of metastasis occurring after vascular penetration, and that it might well be primarily concerned with the growth of cells that have already been disseminated systemically; under these conditions it would be expected that different tumors might well respond differently. The use of the intravenous injection technique for the study of metastasis introduces several additional factors not seen when spontaneous metastasis occurs, such as the introduction of many dead as well as living cells, and the introduction of material from another host. In the present experiments (*4*) use has been made of a technique of implantation into the tail, subsequent complete removal of the tumor, and study of cells disseminated previous to excision.

The tumor used was a transplantable carcinoma originally from the bladder epithelium of a C57 black mouse, designated as T150, and subsequently carried in the C57 black strain. The tumor was ground in saline, and the suspension diluted to provide a concentration of 10^7 cells/cm^3; 0.05 ml of this suspension was injected subcutaneously into the tail with a 22-gage needle. The injection was directed caudally to avoid spread toward the base of the tail. Under these conditions a viable tumor growth appears on the 14th to 19th day following injection, reaches a size of 1 cm in diameter in 2 days and then spreads rapidly, invading the subcutaneous tissue of the caudal region of the body. There are three possible mishaps that may occur with this procedure: (i) in some 10 percent of cases the tumor may fail to grow at all; (ii) in some 8 percent of this material the tumor grew diffusely down the tail, instead of as a localized mass; (iii) in scattered instances the injection was made directly into the tail vein, noted at first by an absence of resistance to the plunger of the syringe, and often by distress and even death of the animal. All these occurrences were taken as indications to discard these particular animals.

Tumor T150 is a spontaneously metastasizing neoplasm, inducing multiple metastases in the lungs that have been described elsewhere in detail (*5*). When the growth in the tail has reached a diameter of 1 cm some tumor emboli are released, and preliminary studies have revealed that a small number of metastatic lesions are noted if the tail is amputated at this stage.

For the present experiment 78 C57 black mice from the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me. were used. They were housed in plastic cages and fed Rockland mouse diet with water ad libitum. The mice were implanted with the tumor in the tail as previously described, and after the appearance of the growth were divided into pairs having tumors of the same size and duration of growth. When the tumors had reached a size of 1 cm the tail was amputated as near the root as possible, and of the pair, one animal was then maintained as a control

Table 1. Incidence of pulmonary metastases in C57 black mice after removal of the primary growth. The animals were paired (one control and one cortisone-treated) according to the time of appearance and size of the primary growth.

Treatment	No. of animals	No. of animals with metastases	Total number of metastases (gross count)
Controls	38	18	56
Cortisone*	40	31	193

* 0.5 mg of cortisone for 5 days following removal of the primary growth.

and the other received either 4 or 5 injections of cortisone on alternate days. The cortisone (Cortisone Acetate—Upjohn) was administered as 0.5 mg in normal saline dose. All the mice were sacrificed at 14 to 16 days following amputation of the tail. The lungs were removed and all metastases counted with the dissecting microscope, the lungs then being fixed in formalin and sectioned for histological study.

The results are shown in Table 1, where it can be seen that of 38 control mice, not treated with cortisone, 20 were completely free of metastases, whereas in the case of the 40 mice treated with cortisone only 3 did not have metastases. Counts of the total numbers of individual metastases revealed an even greater difference, the control group having 56 and the mice treated with cortisone having a total of 196 macroscopic lesions. The time at which the primary tumor reached a size of 1 cm had no influence on the number of metastases; it can be seen from Table 2 that the behavior of tumors arising on the 14th day was the same as for those arising on the 20th day. The metastases in the cortisone-treated animals were consistently larger than those in the control group. In the latter the lesions ranged in size from 0.5 to 3.0 mm, 60 percent being between 1.0 and 1.5 mm in diameter, whereas in the cortisone treated group they ranged from 1 to 5 mm, 80 percent being between 2 and 3 mm in diameter.

The results of this experiment would seem to confirm the view suggested by Pomeroy that cortisone has an action in stimulating metastasis that acts, at least in part, on the phase of the process that occurs after vascular dissemination. This action seems to be analogous to the action of cortisone in prolonging the life of incompatible grafts of normal tissues in the rabbit (*6*) and in the heterotransplantation of tumors (*7*). In keeping with suggestions proposed to explain these other actions of cortisone, it appears most acceptable to consider this action as one mediated through the host.

Table 2. Incidence of pulmonary metastases in C57 BL/6 mice in relationship to the time of appearance of the primary growth after implantation in the tail.

Time of appearance (days)	14	15	16	17	18	19	20
No. of animals	8	14	12	15	14	8	7
No. of animals without metastases	3	5	4	5	6	3	3
No. of metastases	25	40	41	46	40	28	29

It is of considerable interest to note that the animals in these experiments contained numbers of latent tumor cells present after the original tumor had been eradicated, some of which grew only after an additional stimulus was provided. Apart from the implications of this experiment in relationship to the action of cortisone, it would seem that this technique has much to recommend it both for the study of metastasis, and particularly as a tool for the screening of chemotherapeutic agents for cancer. The mouse containing disseminated tumor cells capable of growing into metastases provides a situation quite analogous with the human being following the surgical extirpation of a tumor. Conceivably some agents may be capable of destroying these isolated cells even though they are incapable of attacking an established tumor mass.

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7 October 1954.

Effect of Hyperventilation on the Human Electroretinogram

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In a previous paper (*1*) a theory was presented that related the rather marked effects of changes in the blood pCO_2 on certain psychophysical visual thresholds (*2*) to processes within the visual cells. Since then experiments on animals (*3*) suggest that the *a*- and *b*-waves of the electroretinogram (E.R.G.) are responses of the visual cells. Dodt (*4*) has shown that hyperventilation (H.V.) is accompanied by changes in the human E.R.G. response to multiple light flashes. Because of the high frequency of the light stimulus in

his experiments it is not possible to deduce from them the way in which the various components of the E.R.G. are changed during H.V. It therefore seemed important to determine whether variation in blood pCO_2 would be associated with changes in the *a*- and *b*-waves of the E.R.G. response to a single flash of light.

Experiments (*5*) were made on two young dark-adapted observers at moderate and high intensities (0.011×10^5 and 1.1×10^5 trolands (*6*) respectively) of stimulus flash (81 msec duration) and under conditions of normal breathing and rather marked H.V. (*7*) in an apparatus previously described (*8*).

The results of these experiments are summarized in Table 1. At moderate intensities, when no *a*-wave appeared in the E.R.G., H.V. was associated with a significant increase in the size of the *b*-wave. At high intensities, H.V. was associated with a significant decrease in the size of the *a*-wave as well as an increase in the size of the *b*-wave. The two components of the *a*-wave (identified here as a_1 and a_2 respectively) described by Armington *et al.* (*9*) were differentially affected during H.V. However, during H.V. the *a*-wave sometimes disappeared completely in certain responses, but this did not occur each time the light was flashed. All of these effects were reversible once normal breathing was resumed. Figure 1 shows data from typical experiments at the high stimulus intensity.

During H.V. the human E.R.G., which at high intensities of stimulus flash is an I-E.R.G. (*10*) assumes the characteristic shape of an E-E.R.G. such as is obtained by our moderate intensity of stimulus flash.

These data suggest then that changes in blood pCO_2 may affect physiological processes within the eye, perhaps at the photoreceptor level. The conversion in the human eye under conditions of H.V. from an I to an E retina suggests that H.V. reduces the magnitude of the PIII component of Granit (*11*). This interpretation implies that H.V. should produce a change in any effect related to the PIII component of the E.R.G. For example, it has been suggested that alpha adaptation (*12*) and meta contrast (*13*) are related to the PIII component. If so, then it seems reasonable to expect rather markedly different results from these experiments when carried out under conditions of H.V.

Table 1. Electroretinogram response to a light flash (81 msec duration) during normal breathing and hyperventilation (two observers).

Retinal illuminance (trolands)	Wave	Normal breathing* (μv)	H.V.* (μv)	Difference	Statistical confidence level
1.1×10^5	b	131 ± 20	174 ± 15	+43	0.01
1.1×10^5	a	109 ± 15	80 ± 28	−29	.01
1.1×10^5	a_1	68 ± 11	62 ± 19	− 6	.2
1.1×10^5	a_2	43 ± 8	19 ± 12	−24	.01
1.1×10^5	b	188 ± 22	216 ± 20	+28	.01

* Mean ± one standard deviation computed from at least 26 responses in each case.

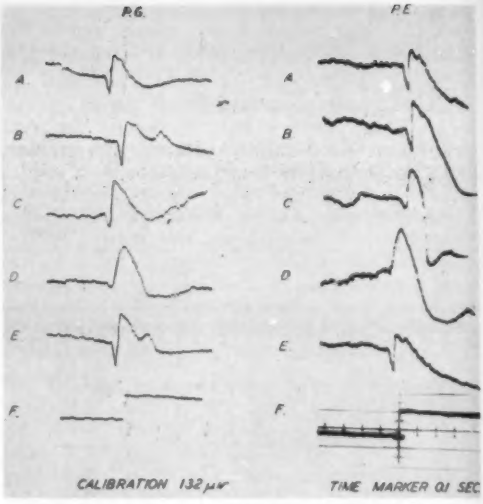

Fig. 1. Effect of hyperventilation on E.R.G. of dark-adapted human being. *P.G.: A*, control response before onset of H.V.; *B*, 1 min after start of H.V.; *C*, 2 min after start of H.V.; *D*, 3.7 min after start of H.V.; *E*, control response after cessation of H.V. and observer reported loss of all subjective symptoms. *P.E.: A*, same as *A* for P.G.; *B*, 2 min after start of H.V.; *C*, 3 min after start of H.V.; *D*, 6 min after start of H.V.; *E*, same as *E* for P.G.

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6. The troland is a unit of intensity of light at the retina, equal to the illuminance received per square millimeter of pupillary area from a surface having a luminance of one candle per square meter.
7. No measurement of blood pH was made. The characteristic symptoms of H.V. appeared usually after 1 min. The intensity of H.V. was approx. equal to that in previous experiments (*1*) in which the blood pH rose about 0.11 units.
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16 August 1954.

A Critical Orifice CO_2 Analyzer Suitable for Student Use

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A simple method for the continuous analysis of carbon dioxide in expired gas has been developed for student use. The following general principle has been used. If a dry gas mixture is passed through a chamber containing a CO_2 absorbent, the volume of gas passing into the chamber in a given time will equal the volume leaving the chamber (under the same conditions of pressure and temperature) if there is no CO_2 in the mixture. If CO_2 is present in the mixture and all of the CO_2 entering the chamber is absorbed, then A, the total volume of gas entering the chamber in a given time will exceed B, the volume leaving the chamber in the same time interval, as related by the equation

$$A = B \times \frac{1}{1 - F_{CO_2}},$$

where F_{CO_2} is the fraction of CO_2 in the entering gas.

In practice the rate of outflow is maintained at a nearly constant level by means of a critical flow orifice (*1*), as shown in Fig. 1. The pressure on the downstream side of the orifice is maintained at less than half an atmosphere by means of a water-jet filter pump. The diameter of the orifice is approximately 0.003 in., permitting a gas flow of about 100 ml/min. The gas sample flows into the chamber through a second orifice of larger diameter (about 0.010 in.). The pressure drop across this orifice is measured and indicates the rate of flow into the chamber. This pressure drop is approximately 10 cm-of-water when dry CO_2-free air is sampled. Since the outflow is maintained at a nearly constant level, the flow through the measuring orifice must increase as the fraction of CO_2 in the test gas increases. For example, if the dry sample contains 5 percent CO_2, the rate of flow through the measuring orifice increases approximately 5 percent from zero CO_2 conditions. In this instance, the measuring orifice pressure drop increases approximately 10 percent, for it varies as the square of the rate of flow through it. To accomplish adequate resolution of such a pressure change, a reservoir manometer is used, slanted at 10° over the operating range and with gauge oil as the fluid (sp. gr. 0.86). The CO_2 absorbent used is Ascarite 8–10 mesh (sodium hydroxide fused on asbestos). Figure 2 is a calibration curve obtained with known mixtures of CO_2 in air. The deflection is approximately 0.05 percent/mm. The response time is approximately 4 min from 0 to 8 percent CO_2. Most of the delay can be attributed to the time required for thermal equilibrium to be established in the CO_2 absorber.

Table 1 shows values obtained by this method and by a standard Haldane gas analyzer on samples of expired air, the range being attained by voluntary

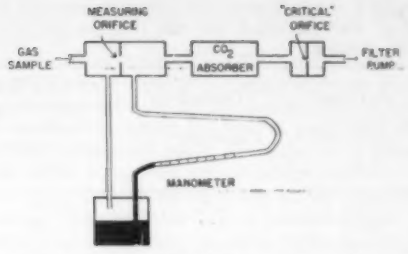

Fig. 1. Schematic diagram of the critical orifice analyzer.

hyper- and hypoventilation. If the Haldane determination has an accuracy of ± 0.02 percent, the accuracy of the critical orifice analyzer, as based on these figures, can be taken to be ± 0.05 percent or better.

The analyzer has proved successful in its intended use in student laboratory exercises. Placed in series with a Pauling oxygen analyzer, both dried alveolar gas—as obtained from a Rahn end-tidal sampler (*2*)—and dried mixed expired gas have been analyzed continuously. With 16 students, alveolar CO_2 partial pressure as obtained during quiet breathing ranged from 35 to 42 mm-Hg with a mean value of 38.6. Bohr dead-space volumes for CO_2 in general fell within 10 ml of O_2 dead-space determinations; the greatest difference observed was 17 ml.

A few practical details of the construction and operation should be mentioned. The orifice holes were drilled in 0.002-in. brass shim stock (*3*). Glass filter paper was placed upstream from each orifice to prevent plugging. In order to maintain the same gas temperature at the two orifices, copper coils of length 25 in. and inside diameter 1/16 in. were placed upstream from each orifice. It was found that it was not necessary to place them in a constant temperature bath.

Because of the influence of gas density on the meas-

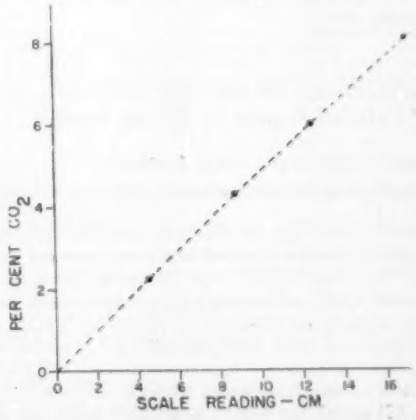

Fig. 2. Calibration curve obtained with known mixtures of CO_2 in air.

Table 1. Comparison of percentage CO_2 obtained by the critical orifice analyzer and the Haldane gas analyzer (seven samples).

Haldane gas analyzer (%)	Critical orifice analyzer (%)	Critical orifice analyzer minus Haldane gas analyzer (%)
2.97	2.94	−0.03
3.56	3.54	− .02
6.45	6.48	+ .03
1.12	1.08	− .04
6.66	6.73	+ .07
1.37	1.33	− .04
6.80	6.86	+ .06

uring orifice pressure drop, the influence of ambient pressure must be taken into account. It was found empirically, from measurements made over a 19-mm range of ambient pressure (756–775 mm-Hg), that a 1-mm change in pressure was equivalent to about 0.04 percent change in CO_2. By adjusting the reservoir level so that on room air, passed through Ascarite before entering the analyzer, an arbitrary zero point in the scale was maintained, the variation with ambient pressure in the range from 3 to 6 percent CO_2 was reduced to less than 0.008 percent per mm-Hg change in atmospheric pressure. In this way small changes in ambient pressure could be neglected, and a single calibration curve served for a day's run (*4*).

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4. I wish to acknowledge the assistance of my father, W. J. Mead, who constructed the manometer, and of Libby Servello, who performed the Haldane analyses. E. M. Landis made possible the use of the analyzer in student exercises and William B. Kinter assisted in supervising its use.

4 October 1954.

Auxin Effects on the Utilization of C^{14}-Labeled Acetate by Wheat Roots

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Several years ago we observed production of acetaldehyde by wheat roots incubated in solutions of auxins (*1*). This effect suggests that the search for a specific chemical event underlying auxin action ought to include a study of reactions of the acetyl group, and prompted the work with acetate-1-C^{14} reported here (*2*).

Roots excised from wheat seedlings (White Federation 38) grown for 4 days in distilled water (*3*) were used. For the 2-hr experiment, 19 g of roots were incubated at 21.5°C in 100 ml of $6 \times 10^{-4}M$ acetate solutions having activities of 242.5 and 229.0 μc, respectively, for the control and experimental treatments. For the 30-min experiment, 3 g of roots were incubated at 23°C in 35 ml of approximately $1 \times 10^{-4}M$ acetate solution having 30 μc of activity. In both experiments, indoleacetic acid (IAA) was used as an auxin at $2.5 \times 10^{-5}M$. Acetate solutions were adjusted to *p*H 4.7 with KOH.

During the experiments, CO_2-free air passed through closed vessels containing the roots, then through a U-tube held at −80°C to trap volatile products, and finally through a gas-washing bottle containing 0.1*N* NaOH to retain CO_2. At the end of the experiment the roots were separated from the solutions and washed. Combined solutions and washings from roots and cold traps were analyzed for C^{14}. These values, together with those for radioactivity in the original solutions and in the CO_2 produced by respiration were used to calculate the total quantity of C^{14} absorbed by the roots in the 2-hr experiment. No measure of C^{14} absorption is given for the 30-min experiment because the decrease in activity of the solution during the course of the experiment was about equal to the analytic error.

Root material in the 2-hr experiment was blended in the cold with water. After filtration this process was repeated three times on the solid material. An aliquot of the combined filtrate (designated "Total water-soluble fraction" in Table 1) was assayed for activity by a wet oxidation procedure (*4*). In this method the organic material is oxidized by chromic acid (*5*), and the gaseous products are carried to an evacuated ion chamber by a stream of CO_2. Activity in the chamber is measured on a vibrating reed electrometer (*6*). Values in Tables 1 and 2 represent averages for two determinations, and in each case duplicate values agree within 3 percent.

Another aliquot of the filtrate was acidified to *p*H 1.0 with sulfuric acid and was extracted for a period of 96 hr with ether. Titration of the ether extract

Table 1. Utilization of acetate-1-C^{14} by wheat roots in 2 hr.

	Control roots (μc)	Roots in IAA $2.5 \times 10^{-5}M$ (μc)	IAA/control times absorption factor*
C^{14} absorbed	214.40	178.97	100
Total water-soluble fraction	121.00	129.50	129
Lipids	1.92	2.15	135
Acidic substances	77.25	89.00	139
Acetic acid (calculated)	71.78	85.65	144
Nonvolatile acids	5.47	3.35	74
CO_2 of respiration	15.70	13.96	101

* Absorption factor equals 100 times the ratio of uptake of C^{14} in the control to that of the auxin treatment.

Table 2. Utilization of acetate-1-C^{14} by wheat roots in 30 min.

	Control roots (μc)	Roots in IAA $2.5 \times 10^{-5}M$ (μc)	IAA/ control $\times 100$
Total 80 percent EtOH extract	0.491	0.461	94
Lipids	.007	.013	186
Ether-insoluble substances	.484	.448	93
Acetic acid	.029	.107	369
Residue of EtOH extract	.467	.317	68
CO_2 of respiration	.018	.011	61

with an aqueous solution of NaOH to *p*H 8.5 effected the separation of an "Acidic substances" (Table 1) fraction that was analyzed for radioactivity. The "Lipids" of Table 1 are materials remaining in the ether. Chromatographic analysis revealed that most of the activity in the acids extracted by ether was due to acetic acid. Aliquots of the solutions of the acidic substances were lyophilized and then acidified with dry HCl in a vacuum line. Volatile acids released in this fashion were distilled into tubes to which excess NH_4OH was added later. Chromatograms of the ammonium salts (*7*) and their radioautographs established that all activity in the volatile-acid fraction resided in acetic acid. The residual, nonvolatile acids were freed of NaCl by lyophylization in the presence of H_3Po_4 and then assayed for radioactivity. Values for acetate in Table 1 were calculated from those for total acidic substances and nonvolatile acids.

Roots from the 30-min experiment were extracted in a closed system with five successive 100-ml portions of boiling 80-percent ethanol that were drawn by suction into a flask containing 40 ml of 0.01*N* NaOH. After removal of the ethanol, this alkaline solution was extracted with ether for a period of 96 hr. An aliquot of the extract, labeled "Lipids" in Table 2, was assayed. Samples of the aqueous residue were assayed and are identified as "Ether-insoluble substances" in Table 2. Another aliquot of the residue was acidified, and steam was distilled to isolate the volatile acids. Residual solutions and steam distillates were assayed, and the radioactive material of the steam distillate was identified by radioautography as acetate.

It is evident that acetate utilization is inhibited by IAA at $2.5 \times 10^{-5}M$, a concentration that also inhibits root growth (*8*). In the 2-hr experiment (Table 1), the auxin-treated roots accumulate more radioactivity in the water-soluble constituents than the control roots do, but it is seen that this difference is due to the higher level of free acetic acid in the former. Acids other than acetic, however, have greater activity in the control tissues, indicating obvious inhibition of acetate utilization by IAA.

It is of interest to see (Table 2) that the inhibitory effect of IAA is evident 30 min after exposure of the roots to auxin. In the IAA-treated roots, there is much more activity that can be assigned to acetic acid than there is in the control roots. The latter have greater activity in the 80-percent ethanol-soluble materials exclusive of acetic acid. One fraction of the 80-percent ethanol extract, probably lipids, extracted from an aqueous, alkaline solution by ether, shows greater activity in the IAA-treated roots.

Boroughs and Bonner (*9*) describe experiments with *Avena* coleoptile tissues in which the effects of IAA on the conversion of acetate-1-C^{14} and other labeled compounds to a number of plant substances were studied. Of all the cellular material analyzed, only the synthesis of noncellulosic polysaccharides is impressively stimulated by IAA. A small stimulation of lipid synthesis occurs, but the synthesis of other cell-wall materials, proteins, and a variety of soluble substances were not appreciably affected.

Our experiments appear to confirm a suggestion arising from studies of auxin-induced acetaldehyde evolution that IAA inhibits the synthesis of citric acid from oxalacetic acid and the acetyl group (*1*). The results may be interpreted as evidence that IAA controls growth by regulating the metabolism of acetyl groups in some fashion, or it may be argued that these effects are, as most auxin responses must be, of a secondary nature and are the consequence of some more profound auxin action. The possibilities for a primary auxin effect involving enzymes of acetylation appear to be strengthened by the recent work of Siegel and Galston (*10*) and of Leopold and Guernsey (*11*) in which evidence for the formation of a thioester of IAA and coenzyme A is presented.

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29 April 1954.

Comments and Communications

Reaction of Bromine Water with Alfalfa Saponins

The recent report that alfalfa saponins are involved in bloat of ruminants has created interest in this group of compounds (*1*). Investigations in our laboratory have been centered on a mixture of saponins isolated from alfalfa by Walter *et al.* (*2*). No pure glycosidic compound has been isolated from this mixture, and paper chromatographic techniques have failed to resolve it into its component parts.

During a cursory examination of the effect of various oxidizing agents on alfalfa saponins we observed that saturated bromine water reacts rapidly with this mixture at room temperature, as evidenced by the disappearance of the bromine color, by the formation of a white precipitate, and by paper chromatographic studies.

Examination of the filtrate from the bromine water treatment by paper chromatography (*3*) revealed three spots on the chromatogram, all of which moved more slowly than the control sugars glucose, arabinose, xylose, and rhamnose. The rate of movement of the three spots suggested an oligosaccharide type of material and the spots gave the characteristic pentose-color reaction with the aniline spray reagent.

When untreated alfalfa saponins are hydrolyzed for two hours with 1*N* hydrochloric acid in a sealed tube in a boiling water bath, paper chromatography always reveals glucose, arabinose, xylose, and rhamnose on the chromatogram. When each of the three carbohydrate fractions obtained from the bromine-treated saponin was hydrolyzed similarly with 1*N* hydrochloric acid, the two slowest fractions were each composed of arabinose, xylose, and rhamnose. These two fractions contain the same sugars, but preliminary studies have indicated that the molecular ratios of the component sugars may be different. The third and fastest fraction consisted of glucose, arabinose, xylose, and rhamnose. The experimental data thus indicate that the bromine water cleaves sugars from the alfalfa saponins in the form of three sugar polymers. It seems appropriate to report these findings at this time because of Potter and Kummerow's (*4*) recent report on the isolation of three triterpene genins from dehydrated alfalfa leaf meal.

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25 October 1954.

Free Amino Groups of Human Serum Albumin

It has been reported by Brand and Van Vunakis (*1*), using Sanger's DNP technique (*2*), and it is confirmed in this paper that there is one free alpha amino group, belonging to aspartic acid, in human serum albumin. The same free amino group was also found in bovine serum albumin by Brand and Van Vunakis.

McClure, Schieler, and Dunn (*3*), using Edman's phenyl isothiocyanate technique with bovine albumin, however, found a number of terminal alpha amino groups, of which two or three were contributed by aspartic acid, one by methionine, one by histidine, and an undetermined number by alanine.

Weber has observed an increased availability of the terminal groups of bovine serum albumin in methyl ethyl ketone. This is demonstrated by an increased rotational freedom of groups in the molecule, presumably about many bonds (*4*). It was postulated that the increased rotational freedom may make accessible to Sanger's fluorodinitrobenzene reagent groups that would otherwise be masked, and that these additional groups might account for the other free alpha amino groups found by McClure *et al.*, but not found by Brand and Van Vunakis.

It was of interest to know whether this might be true for human serum albumin. The DNP reaction was carried out first in the usual way as described by Sanger (*2*) by adding 1 g of 1:2:4 fluorodinitrobenzene (FDNB) in 10 ml of 95-percent ethyl alcohol to 0.5 g of human serum albumin dissolved in 5 ml of 10-percent sodium bicarbonate, *p*H 8.5. The mixture was shaken for 2 hr. The insoluble DPN albumin was washed three times each with water, alcohol, and ether, and then it was air-dried. A second sample was prepared in the same manner except for the fact that the FDNB was dissolved in 10 ml of methyl ethyl ketone, and the albumin was dissolved in 5 ml of a 10-percent solution of sodium carbonate, sodium bicarbonate, *p*H 9, the *p*H at which McClure's group worked. One hundred milligrams of air-dried DNP albumin were found by Thompson (*5*) to contain 79 mg of moisture-free albumin by amide determinations, and these figures were used here. Fifty-milligram samples of each preparation were hydrolyzed in 5.7*N* HCl by boiling under reflux for 4 hr and for 24 hr. DNP amino acids were identified by silica gel and filter paper chromatography (*2, 6*), the silica gel chromatography being quantitative. Control experiments showed that there was a 65-percent breakdown of DNP aspartic acid during 24 hr of hydrolysis. The 15-percent breakdown in 24 hr for the epsilon DNP lysine used was that reported by Sanger (*2*).

The results were the same in aqueous methyl ethyl ketone as in aqueous ethanol: one alpha amino group of aspartic acid (0.365 and 0.345 after 24-hr hydrolysis, corrected to 1.04 and 0.98, respectively) and

an average of 57 epsilon amino groups of lysine (56 and 59, respectively) per molecule of human serum albumin, molecular weight 69,000. There was no apparent freeing of additional alpha amino groups of human serum albumin detectable by this method.

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24 September 1954.

Importance of Proteases as Factors Involved in the Exsheathing Mechanism of Infective Nematode Larvae of Sheep

The importance of pepsin as a factor influencing the exsheathment of third-stage infective nematode larvae in the host has been raised by Crofton (*1*). Working with *Trichostrongylus retortaeformis* from the rabbit, he obtained a high rate of exsheathment by using solutions of pepsin in hydrochloric acid. Solutions of hydrochloric acid alone and of distilled water gave no exsheathment, and boiling the pepsin solutions rendered them inactive.

The researches of Poynter (*2*), however, on infective nematode larvae of parasites of the horse indicate that enzymes do not have a role in the exsheathing mechanism. Sommerville (*3*) recently obtained rapid exsheathment *in vivo* with several species of infective larvae of sheep by using cellophane dialysis membranes in fistulas of the rumen and abomasum. Exsheathment has similarly been obtained in this laboratory at a slower rate and using an abomasal fistula only.

Further evidence that enzymes do not play a part in the exsheathing mechanism of infective larvae of sheep has been obtained by studying the action of pepsin and trypsin on the cast cuticle of *Haemonchus contortus*. Separation of the cuticle was obtained as previously described (*4*). Pepsin was made up in the manner described by Hollaender *et al.* (*5*), and trypsin was made according to the method of Moscona (*6*). The potency of these solutions was tested by using controls containing muscle fibers. Experiments were carried out at 38°C over a period of 3 days, and in no case did hydrolysis of the cuticles occur.

It has been shown that proteins that have a very low aromatic amino acid content, such as gelatin, have a correspondingly slow peptic hydrolysis, and that proteins that contain many aromatic amino acids are hydrolyzed rapidly by pepsin. Recent investigations by Baker (*7*) have shown that dipeptides containing two residues of the *l* form of the aromatic amino acids phenylalanine, tyrosine, and diiodotyrosine are hydrolyzed more rapidly than any previously known synthetic peptide, indicating that the specificity of pepsin is related to the hydrolysis of peptide linkages involving aromatic amino acids. The studies of Hofmann and Bergmann (*8*) on the specificity of trypsin indicate that this is directed to the hydrolysis of peptide bonds involving arginine and lysine.

It has recently been shown that the cuticle of infective larvae of *H. contortus* is composed of proteins, which, however, lack the aromatic amino acids lysine and arginine (*4*). The failure of the proteases to attack the cuticle of the larvae can, therefore, be attributed to the chemical composition of the constituent proteins. It is of further interest to note that more rapid exsheathing rates were obtained in distilled water in which the cuticle had been shown to be soluble at higher temperatures than in solutions of pepsin similar to those used by Crofton (*9*).

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9. I am indebted to the McMaster Laboratories, Glebe, N.S.W. for supplies of larvae of *H. contortus*, to I. G. Jarrett, C.S.I.R.O., Division of Biochemistry and General Nutrition, Adelaide, for preparing the abomasal fistula, and to the Agricultural Research Council.
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14 October 1954.

Earthworm Breeding Farms

I have read with interest the news item on earthworm breeding farms [*Science* **120**, 825 (1954)]. It seems necessary that a note of caution be introduced in evaluating the ability of worms to enhance the chemical and physical properties of soil. For example, Chadwick and Bradley [*Proc. Am. Soc. Hort. Sci.* **51**, 552 (1948)] concluded after an extensive series of experiments that although castings are beneficial when added directly to potted plants, the presence of large numbers of worms in the soil had no beneficial results upon plant production. Different species of worms have a strong selectivity for various types of soil.

With regard to this fact it is interesting to note that *Eisenia foetida* is one species that is commonly supplied by worm farms. While easy to culture, the worm is restricted to a habitat of manure or compost, and will die when placed in the loamy soil of the field or garden. Hence any increase in yield from soils to which this species has been added is of a transient nature, being the result of the worms' decomposition

and not their activity. The statement that the farm worms contribute significantly to flood relief in the Netherlands is open to question, for it is well known that earthworms have a low tolerance to carbon dioxide and will perish in most water-logged soils. The Darwin estimates of yearly soil turnover by worms at 400 lb/acre would more properly read from 7 to 18 tons per acre, per yr.

In general it can be said that worms are abundant in well-aerated soils of high organic content, but it is doubtful whether they actually improve poor soil conditions because their action is most likely effective only in the maintenance of good soil properties already present. The organic gardener should look with some skepticism on the claims for the benefits derived from the introduction of worms into soil and at least should be certain that worms supplied by the earthworm farmers are of a species known to inhabit the type of soil into which they are to be introduced.

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9 December 1954

A Scattering Layer Observation

The deep-scattering layer has been shown to be present over most of the oceans with the possible exception of the polar areas. It is generally believed to consist of marine organisms, and one of its remarkable features is the constancy with which it shows on an echo sounding record as a ship moves along. This constancy is surprising in view of the relative patchiness of plankton indicated by the towing of continuous plankton samplers (*1*).

At the depth of the scattering layer an echo sounder indicates only the presence or absence of a scatterer within a large area. In an effort to obtain better resolution in recording the layer a transducer was lowered to various depths. With the echo sounder set on its shortest range, only a small volume of sea was returning echoes at any one time. The drifting of the ship moved the transducer through the water and resulted in scanning. Figure 1 shows the type of record obtained under these conditions. Two conclusions can immediately be drawn. First, the scattering is patchy as though it was caused by individuals or small schools. Second, the size of the "individuals" is small relative to 25 ft. This is indicated by the concave underside of the patches on the record even at ranges as short as 50 ft. As the scatterer passes through the beam its distance from the transducer varies. It is initially further away, reaches a point of closest approach directly beneath the transducer and then again recedes as it passes out of the conic sound beam. If the scatterer were longer than the beam width it would return sound from a greater range when part of it was at a minimum range. Since this is not the case even at a range of 50 ft, where the sound beam is 25 ft wide, the second conclusion seems justified.

The velocity of the scatterers relative to the transducer can be computed from the curvature of the upper sides of the patches. Nearly the same value is obtained for all patches; therefore it would seem that the scatterers are not affected by the sound and are not moving about randomly. For this reason it is straightforward to count the number of patches in a known volume of water scanned and calculate their density.

So far it has been possible to do this only outside the scattering layer. The scatterers occur on the average of one for every 3×10^5 ft^3 of sea. This is in agreement with the frequency of large individual echoes found by Raitt (*2*) outside the scattering layer in the Pacific Ocean. It is also in substantial agreement with the numbers of fish caught by a mid-water trawl of efficient design described in some unpublished work of Backus. Backus' investigation was made in the same area of the Atlantic as ours.

The scattering layer in the North Atlantic is usually best developed during the day at a depth of about 250 fathoms. Consider that some transducers are sensitive over an angle of about 30 deg. Then from the surface the sound beam is sampling a circular section of the layer 750 ft in diameter. Echoes are returned from a thickness of half a pulse length, which for the records here is 20 ft. The volume of sea returning sound at any instant is then about 10^7 ft^3.

Unfortunately the only figures here are for outside the main region of scattering. Even in this sparsely populated area there are 30 individuals in the sound beam at one time. Backus (personal communication) reports a density of fish in the layer that would place at least 500 in the beam at one time. Marshall (*1*) has presented plausible evidence that bathypelagic fish are widespread and nonschooling in behavior. It is not surprising then that the scattering layer record appears continuous. Such a large average number would only rarely be expected to fluctuate to a low value and thus give no echo.

Work will be done to narrow the cone angle and

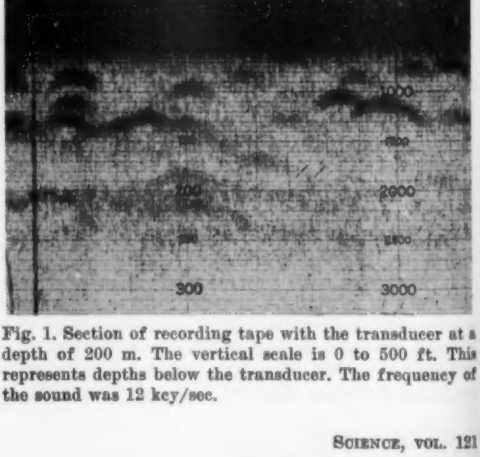

Fig. 1. Section of recording tape with the transducer at a depth of 200 m. The vertical scale is 0 to 500 ft. This represents depths below the transducer. The frequency of the sound was 12 kcy/sec.

shorten the pulse length. This will permit the counting of scatterers in more densely populated regions. In addition, a measurement of the echo intensity will help to establish the size range of the scatterers. The possibility exists of using a surface-controlled camera in conjunction with the transducer. This should constitute marked improvement over the random picture-taking technique now in use.

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1 November 1954.

Pure Cultures of Fungi Produced by Ants

Experiments and observations elucidating the mechanisms by which pure cultures of fungi are cultivated and maintained in the nests of attine, or fungus-growing, ants have been conducted in Panama and Florida in 1954, and at Swarthmore College in 1953–54, with similar results. The ants' habit of stripping the leaves of economic plants causes the larger attine species to be ranked as major agricultural pests throughout much of Latin America. Heretofore, an explanation for the ability of the ants to create pure cultures of fungi despite the constant bringing in of alien bacteria and fungi has been lacking.

The attine ants are found exclusively in the New World and primarily in the tropical regions. The fungi that the ants cultivate have not been recognized outside of ant nests, and the ants are dependent on the fungus for their food supply. In most of the species, a nest, consisting of one or more chambers in which a fungus garden is developed, is formed in the soil. The fungus garden is usually formed on a vegetal substrate, such as triturated leaves. Removal of the ants from a fungus garden causes it to be soon overwhelmed by alien fungi and bacteria. The fungi are clearly unable to maintain themselves and do not grow except under the care of the ants.

The northernmost of the fungus-growers, *Trachymyrmex septentrionalis* McCook from New Jersey, has been kept under observation since September 1953, at Swarthmore. Two types of fungi appear regularly in the artificial cultures and have been cultured on potato dextrose and Sabouraud's agar. A few workers are able to maintain a fragment of fungus garden in its normal condition on an agar plate, despite flourishing alien fungi of *Penicillium*, *Aspergillus*, and *Mucor* types and bacterial colonies that are close to the garden. The ants walk over these regularly as they forage for substrate.

In Panama, fungus gardens and parts of colonies of *Cyphomyrmex costatus* Mann and species of *Atta*, *Trachymyrmex*, and *Apterostigma* were kept under observation at the Gorgas Memorial Laboratory, and their fungi were cultivated on Sabouraud's agar. Several types of fungi were produced. *Atta* and *Trachymyrmex* strains produced bromatia, a concentrated form of gongylidia that is eaten by the ants, and which grew in these artificial cultures much as in ant nests. These were fed back to the ants after culturing for 2 mo or more. The ants accepted them as food and used them as a nucleus for a fungus garden. As at Swarthmore, it was found that the ants of these genera could maintain fragments of fungus gardens in the pure condition on agar plates despite a forest of surrounding alien fungi.

At the Archbold Biological Station in Florida, *Trachymyrmex septentrionalis seminole* Wheeler and *Cyphomyrmex rimosus minutus* Mayr were kept under observation in the same manner. Ants of *T. septentrionalis seminole* from Florida adopted and cultivated fungus gardens of the New Jersey form at Swarthmore.

This Florida *Cyphomyrmex* fungus developed, on Sabouraud's agar, two strains quite different from that of the Panama *Cyphomyrmex costatus* or from that of any of the other attines. One strain developed a morel-like or vermiculate form that has been recorded in the literature [*Rev. de Ent.* **16**, plate 1, Fig. 2 (1945)], and which the author developed in 1935 from the same ant in Trinidad. After the fungus had been reared in artificial culture for more than a month, it was fed back to the ants, which used it as food and cared for it as though it were their normal fungus.

On the basis of these and other data to be published more extensively elsewhere, it is postulated that the salivary and anal secretions of the ants may play a primary role in creating conditions for pure cultures of ant fungi. Identifications of these fungi are desired, and cultures will be submitted to mycologists upon request.

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27 September 1954.

Modern Cosmology and the Fixed Stars

Herbert Dingle's article, "Science and modern cosmology" [*Science* **120**, 513 (1 Oct. 1954)] is a most provocative and explicit statement of the uneasiness and dissatisfaction that any thoughtful student of modern cosmology must feel. It might be remarked, however, that this unhappy situation cannot wholly be blamed on the "newer" cosmologies; it reflects as well a growing realization that general relativity itself is inadequate to the claims that are often made in its behalf.

Dingle, of course, makes no such rash claims, and rightly stresses the *relativity* of the theory, the emancipation of physical reality from coordinate systems. This, with the allowance for curved metries and consequently the incorporation of gravitational "forces" as inertial effects, is the great advance—and it is truly

an advance in physical understanding of an observed world.

The claims sometimes made for the "Mach principle," on the other hand, are misleading. We have *not* reached any further understanding of inertial effects per se; Einstein's metric is still "Euclidean in the small"; a Foucault pendulum still mysteriously honors the distant configuration of Newton's fixed stars. Here indeed we have real physical facts, as unexplained now as when Ernst Mach was writing. So might not our "younger cosmologists," as they peruse the history of science, profitably also contemplate the mystery of absolute rotation, and search for the illuminating principle, yet to come, that will explain accelerative "forces," and relate the great, small, and distant in our universe? This must surely be a problem for physical insight, with mathematical ingenuity only of accessory use.

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29 October 1954.

Acclimatization?

Carroll B. Nash has presented some very interesting data on heat death temperatures and exposure times for *Goniobasis livescens* [*Science* 119, 773 (1954)]. For this he deserves commendation. I seem, however, to perceive some important implications in his data that are not brought out clearly in the text.

Reference to Table 1 of his paper shows that greater mortality occurred among the slowly heated snails than among the quickly heated ones when the time of exposure to the *maximum* temperature was short. As this exposure time was extended to 30 min and longer, the rapidly heated snails died just as often as the slowly heated ones. It appears as if this were direct evidence that heat penetration was forcing an increase of internal temperature during the longer exposure periods.

Evidently most *G. livescens* will die if they are exposed for 60 min to a temperature of 36°C, that is, if their internal temperature is elevated to this point. Consider, then, what happened to the "acclimatized" group, which, having been held at 36°C for 5 min, was heated to 37°C for 5 min, then to 38°C and so on, and was finally warmed to 41°C for 1 min and then cooled. Their complete mortality simply suggests that they were heated through, and, as is the case with many creatures, their "constitution" simply could not stand that. The rapidly heated group, however, suffered very little from their 1-min exposure because they were clearly not heated through in the time allotted.

It is unfortunate that Mr. Nash has not presented the weights of the individuals that died or survived in each test. Since the weights varied from 0.3 to 1.1 g, and the volumes, therefore, varied in this same ratio, it is clear that the smaller individuals underwent a much more severe test than the larger ones because of their much larger surface area/volume ratio. It would be interesting to know whether the individuals that died when rapidly heated for 5 and 10 min were the small ones of their respective groups.

The data, therefore, tell nothing about "acclimatization" except that it is dubious. The pertinence of "rate of heating" can be established by simple relationships between thermal conductivity and size of the individual snail.

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24 November 1954.

With the exception of the presumed relationship between the size of the snail and its rate of heating, I find no implications in the data cited by Dingle that are not apparent in the original article. The snails were divided into groups of "large," "medium," and "small" individuals, with the same ratio of individuals of these three groups in each of the 87 sets of snails. Because of this, it is unlikely that the surface area/volume ratio significantly contributed to the differences of mortality rate in the several sets of snails. No correlation between mortality rate and body size was apparent from the data, and the individuals that died when rapidly heated for 5 and 10 min were not disproportionately representative of the "small" snails.

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6 December 1954.

Relationship of Motive to Author and Statement

The question of how beliefs and feelings are changed has been a persistent problem in social psychology. Clearly, the question is important, for an answer would also provide information on such related problems as conformity, uniformity of ideas, and persuasion.

It has been known all along that people change their ideas, not necessarily all at once, but subtly and unconsciously. It was once felt that these changes were brought about in a mechanical, thoughtless, and irrational fashion. However, Asch (*1*) showed experimentally that changes in beliefs and ideas are not mechanical and irrational, but that cognitive factors are involved.

As an example, one finds a higher degree of acceptance for the statement "There is nothing sacred about the American Constitution. If it doesn't serve its purpose it should be changed as often as necessary" when it is attributed to Franklin D. Roosevelt instead of to Earl Browder. Asch's contribution was to show clearly that, with the change in attribution,

the entire context changes and therefore the cognitive content of the statement changes as well. In other words, the statement *means different things* when different people say it and, therefore, is not actually the same statement.

An additional variable that has not received experimental investigation is motive. How is motive related to the acceptance of a statement and to the acceptance of an author? This communication describes a study that was designed to answer this question.

Ten controversial statements ranging from political (for example, the preceding statement) and economic through social and biological (for example, "Intermarriage between whites and Negroes should be forbidden") and general (for example, "The 'facts of life' should not be taught in public schools"), were attributed to two groups of 10 different authors deemed likely to be generally held in either high or low esteem (*2*). For one group of testees, the authors listed were Bernard Baruch, Robert A. Taft, Ernest Hemingway, Adolph Hitler, Earl Browder, Herman Talmadge, Westbrook Pegler, Andrei Vishinsky, Geoffrey Fisher, and Woodrow Wilson. For another group, they were Klaus Fuchs, Joseph McCarthy, Dimitri Shostakovich, Donald Blanton, Franklin D. Roosevelt, Joe Louis, Dorothy Barclay, John Cabot Lodge, Hewlett Johnson, and Nicolai Lenin.

Each item consisted of the statement and its supposed author. The testee was asked to rate on one nine-point scale his degree of agreement or disagreement with the statement and on another nine-point scale his degree of respect and admiration or lack of it for the author of the statement; finally he was asked to describe what he thought were the author's motives.

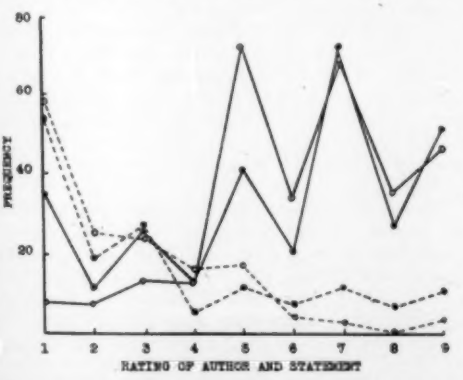

Fig. 1. Frequency of attributed praiseworthy and condemnable motives as a function of the rating of the author and statement. ○——○ denotes the frequency of attributed praiseworthy motives as a function of the author; ●——● denotes the frequency of attributed praiseworthy motives as a function of the statement; ○- - -○ denotes the frequency of attributed condemnable motives as a function of the author; ●- - -● denotes the frequency of attributed condemnable motives as a function of the statement.

With 57 college students, each rating 10 authors and 10 statements and each attributing motives for 10 statements (30 students had the first set of 10 authors; 27 had the second set), 570 motives resulted. These motives were put in three categories: *praiseworthy, condemnable,* and *cannot evaluate.* Of the 570 items, 23 were arbitrated by a third judge because our classifications of them did not agree. The main results are summarized in Fig. 1 and may also be stated as follows (*3*):

1) The greater the esteem with which an author is held, the greater the tendency to attribute good motives to what he says, regardless of what he says.

2) The more one agrees with a statement, the greater the tendency to attribute good motives to the author, regardless of who he is.

3) The less the esteem with which an author is held, the greater the tendency to attribute bad motives to what he says, regardless of what he says.

4) The more one disagrees with a statement, the greater the tendency to attribute bad motives to the author, regardless of who he is.

Clearly, statement and author are not independent, and the facts shown by Asch are, without question, also present in these data. In this regard, it is of interest to note that, when good authors and liked statements (ratings 6 to 9) are coupled, out of 133 attributed motives only four were negative. On the other hand, it is somewhat easier to find good motives when bad authors and disliked statements (ratings 1 to 4) are coupled (out of 138 attributed motives, 19 were positive). Furthermore, the author, as one would expect, has more pulling power than the statement; that is, a good author (ratings 6 to 9), irrespective of statement, produced only eight negative motives. A good statement (ratings 6 to 9), irrespective of author, produced 36 negative motives. A bad author (ratings 1 to 4), irrespective of statement, produced 42 positive motives, but a bad statement (ratings 1 to 4), irrespective of author, produced 82 positive motives.

Further studies already in progress are designed to show not only the relationships between motive and other variables but also to explore the degree of "pulling power" that motive itself has over these variables.

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References and Notes

1. S. E. Asch, *Psychol. Rev.* **55**, 5 (1948).
2. The testees were told after the experiment that the statements were not made by the author specified and that in one case (Blanton) the author was a fictitious person. All testees agreed, however, that the statements *could have been made* by the authors given.
3. The large differences between the frequencies at 2, 4, 6, and 8 in contrast with those at 1, 3, 5, 7, and 9 are an artifact of the rating scale itself. This, however, does not invalidate the results obtained.

10 September 1954.

Mineral Nutrition and the Size of Local Lesions Induced by Tobacco Mosaic Virus*

In connection with certain experiments dealing with the influence of mineral nutrition on the susceptibility of *Nicotiana glutinosa* to infection by tobacco mosaic virus, it was observed that certain treatments consistently altered the size of the local lesions produced on this host.

Essentially the same techniques as were employed previously for the culture of *N. tabacum* were used for *N. glutinosa* (*1*). Details will be published in a later communication. Calcium nitrate and magnesium sulfate were replaced by the corresponding sodium salts, magnesium sulfate was replaced by the chloride, and the iron salt was omitted to induce deficiencies of calcium, magnesium, sulfur, and iron, respectively. Five magnesium-deficiency experiments and four each of the other deficiency experiments were performed, with 32 to 80 plants per experiment. The experiments were carried out from 1952–54 at different seasons of the year. All plants in a particular experiment were inoculated after pronounced, characteristic deficiency symptoms (*2*) had developed.

Calcium and magnesium deficiencies had no apparent influence on the size of subsequently formed local lesions. Both iron and sulfur deficiencies, however, consistently produced larger lesions than those that developed on control leaves, by a factor of two to three estimated visually.

Samuel (*3*) observed that the response of *N. glutinosa* to infection by tobacco mosaic virus was markedly influenced by temperature. Local lesion size increased by increasing the temperature to 35°C; above this temperature no necrosis was observed, and systemic infection occurred. McKinney and Clayton (*4*) noted the production of mosaic symptoms at high temperatures in *Nicotiana* spp. carrying the factor for necrosis at 75°F, which agrees with Samuel's findings.

On *N. glutinosa*, tomato bushy stunt virus produces larger local lesions on young leaves than on old leaves (*5*). Apparently, on the basis of our findings, mineral nutrition can also influence lesion size. In addition, if increased lesion size in general represents a tendency toward systemic infection, mineral nutrition may affect the spread of plant viruses in a heretofore unrecognized manner.

M. Chessin
H. A. Scott

Department of Botany,
Montana State University, Missoula

References and Notes

* Aided by grant G 4111 from the Division of Research Grants, National Institutes of Health, U.S. Public Health Service, and by the Research Committee, Montana State University. Based partly on a portion of the thesis submitted to the Graduate School, Montana State University, in partial fulfillment of the requirements for the degree of Master of Arts.

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15 November 1954.

Note on the Dating of Terraces in the Lake Melville District, Labrador

In the autumn of 1952 a large number of fossil trees were found in a bank of the Crooked River, about 40 mi north of Lake Melville near the head of Grand Lake, Labrador. These trees occurred in a deposit about 5 ft thick, 15 ft above the river level, and 25 to 30 ft above present-day sea level. There are more than 100 trees in this deposit and all are lying horizontally, where they have recently been exposed by the river's cutting back the bank. There is 10 ft of sand above the trees to the top of the terrace, while the bedded material below and around the trees is part clay, part sand. Although no marine shells were found in the bedded clays, in other terraces on the Hamilton River at this lower level the marine mollusks *Mytilus edulis* L. and *Saxicava arctica* were found. The specimens vary in size from small sticks to logs exceeding 1 ft in diameter; some appear to have been burned. The logs have been perfectly preserved in the damp sand and clay, and several samples were taken for dating by the carbon-14 method. They have not yet been specifically identified, but are large and massive, indicating vigorous growth.

The radiocarbon dates of these logs have been determined in the laboratories of the University of Saskatchewan under the supervision of K. J. McCallum. Tests on three different portions of the wood samples gave age values of 2022 ± 195, 2110 ± 245, and 1611 ± 217 yr. The average age was 1914 ± 127 yr. This set of samples bears the serial number S.1 in the Saskatchewan list.

This would indicate that there has been a rather slow rise of the land in this particular area (that is, a maximum of 25 ft in the last 2000 yr), unlike the areas around Hudson Bay where the rise is allegedly something of the order of 3 ft per century. The dates correlated in an interesting fashion with those reported by Potzger and Courtemanche from the James Bay district of Quebec [*Science* **119**, 908 (1954)].

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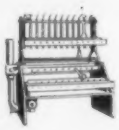

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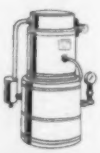

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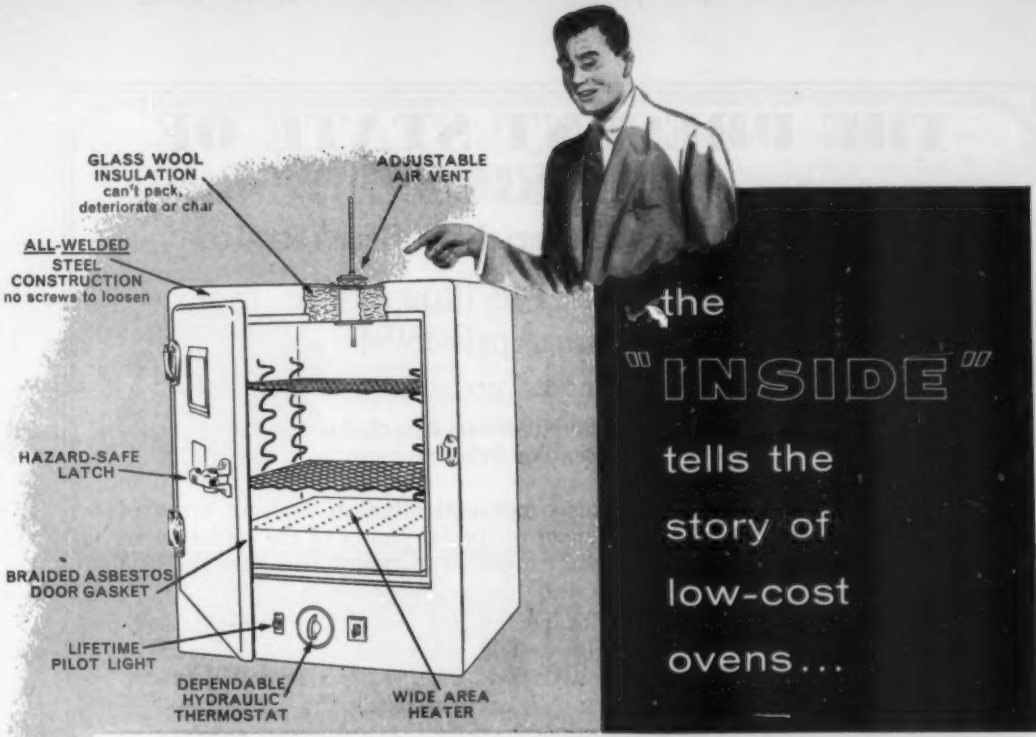

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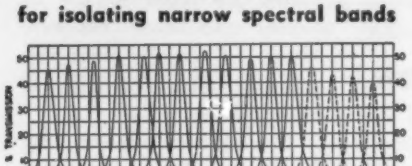

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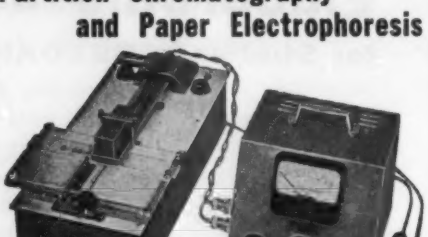

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Scientific journals, even those printed on the same presses, differ unaccountably, unpredictably, and actually unreasonably in their editorial requirements. Most demand one, some two, and some even three copies, double- or triple-spaced, of any manuscript intended for publication. Some journals specify original and unmounted drawings, others insist on unmounted photocopies, while still others request photographic negatives. Footnotes, marginal notes, appended material, textual references, and quotations must be prepared differently for each journal or family of journals.

References are a particular problem. There seems to be no end of ways to cite Adams and Zinn who published a note in 1939. They may appear as a subscript $_1$, superscript ^{1}, or parenthetical number (*1*), chronologically, alphabetically, or in order of appearance, or grouped with half a dozen other references. It may be proper form to mention them by name, or only by number. In the "Bibliography," "References," or "Literature Cited" Adams and Zinn may be listed with complete names or by initials (reversed or not). The title of the article may be included or omitted as in *Science*, and the journal spelled out in full along with the place of publication, or abbreviated in half a dozen ways.

Such variability hampers manuscript preparation. Conforming to an unfamiliar journal style may require several days of rewriting and checking. If carried out imperfectly it hinders consideration of the manuscript and may require a lengthy trip back and forth for revision, while drawing on the editors' time and patience. And, at the end of the line, an unfamiliar publication style slows up reading until superscript numbers, asterisks, daggers and time-table symbols are decoded, and until the authors' institution is located in the hedgerows of acknowledgements and listings of contract numbers.

These differences in editorial requirements and styles of publication, though expressing journal individuality, are not the result of differing printers' requirements. On the contrary, it is often a burden for the printer to keep up with diverse journal styles, and it is a problem to cope with mounted glossies for journal A and unmounted originals for journal B. This, too, helps to delay "communication."

As a practical suggestion there should be some common agreement on the preparation of manuscripts, the number of copies required, the use (or nonuse) of photocopies and mounts, text references, and the extent to which citations are listed in full. Such agreements, of course, would have to be reached by journal editors themselves, after reviewing their common problems, and after weighing the advantages of completeness against the minor economies gained by eliminating titles and complete pagination. But such agreements would benefit authors, editors, printers, abstracters, and readers—all links in the chain of scientific communication.

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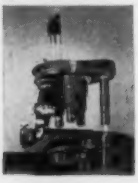

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28–1. American Orthopsychiatric Assoc., 32nd annual, Chicago, Ill. (M. F. Langer, AOA, 1790 Broadway, New York 19.)

28–2. American Educational Research Assoc., St. Louis, Mo. (F. W. Hubbard, 1201 16 St., NW, Washington 6, D.C.)

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3–4. American Assoc. of University Professors, Gatlinburg, Tenn. (R. E. Himstead, AAUP, 1785 Massachusetts Ave., NW, Washington 6, D.C.)

7–9. Chemical Inst. of Canada, Divisional Conf. of the Chemical Engineering Div., Ottawa, Ont. (W. M. Campbell, Box 323, Deep River, Ont.)

7–11. American Soc. of Photogrammetry, Washington, D.C. (C. E. Palmer, 1000 11 St., NW, Washington 1.)

7–11. National Assoc. of Corrosion Engineers, 11th annual, Chicago, Ill. (A. B. Campbell, 1061 M & M Bldg., Houston 2, Tex.)

9–11. American Cong. on Surveying and Mapping, 15th annual, Washington, D.C. (W. S. Dix, Room 435, Woodward Building, Washington 5.)

10–12. M. D. Anderson Symposium on Fundamental Cancer Research, Houston, Tex. (Univ. of Texas, M. D. Anderson Hospital and Tumor Institute, Houston.)

14. American Educational Research Assoc., Denver, Colo. (F. W. Hubbard, 1201 16 St., NW, Washington 6, D.C.)

14. Wildlife Soc., Montreal, Canada. (D. L. Leedy, Fish and Wildlife Service, Washington 25, D.C.)

15–17. Electrical Utilization of Aluminum, American Inst. of Electrical Engineers, Pittsburgh, Pa. (N. S. Hibshem, AIEE, 33 W. 39th St., New York 18.)

17–19. American Physical Soc., Baltimore, Md. (K. K. Darrow, Columbia University, New York 27).

17–19. International Symposium on Cardiovascular Surgery, Detroit, Mich. (John Keyes, Henry Ford Hospital, Detroit 2.)

17–19. National Wildlife Federation, Montreal, Canada. (C. H. Callison, 232 Carroll St., NW, Washington 12.)

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April

1–5. Japan Medical Cong., Kyoto. (M. Goto, Univ. Hospital, Kyoto Univ., Kyoto.)

2. Kappa Delta Pi, Cleveland, Ohio. (E. I. F. Williams, 238 E. Perry St., Tiffin, Ohio.)

3–6. American Astronomical Soc., Princeton, N.J. (C. M. Huffer, Washburn Observatory, Madison 6, Wis.)

3–7. American College Personnel Assoc., Chicago, Ill. (C. Evans, Univ. of Indiana, Bloomington.)

4. American Educational Research Assoc., Cleveland, Ohio. (F. W. Hubbard, 1201 16 St., NW, Washington, 6, D.C.)

4–5. Histochemical Soc. Symposium, Philadelphia, Pa. (A. B. Novikoff, Waldemar Medical Research Foundation, Port Washington, N.Y.)

4–5. National Gastrointestinal Cancer Conf., sixth, New York, N.Y. (Morris K. Barrett, National Institutes of Health, Bethesda 14, Md.)

4–6. American Assoc. of Physical Anthropologists, Philadelphia, Pa. (J. L. Angel, Jefferson Medical College, 307 S. 11 St., Philadelphia 7.)

5. Tissue Culture Assoc., annual, Philadelphia, Pa. (M. R. Murray, TCA, College of Physicians and Surgeons, New York 32, N.Y.)

5–7. Radio Technical Commission for Aeronautics, spring assembly meeting, Los Angeles, Calif. (RTCA, Room 2036, Building T-5, 16th and Constitution Ave., NW, Washington 25, D.C.)

6–8. American Assoc. of Anatomists, Philadelphia, Pa. (N. L. Hoerr, 2109 Adelbert Rd., Cleveland 6, Ohio.)

8–9. Pennsylvania Academy of Science, Philadelphia, Pa. (K. Dearolf, Public Museum and Art Gallery, Reading.)

9. South Carolina Acad. of Science, Columbia, S.C. (H. W. Freeman, Univ. of South Carolina, Columbia.)

10–15. American Inst. of Homeopathy, Washington, D.C. (W. R. Huntsman, AIH, 1601 Chestnut St., Philadelphia 3, Pa.)

10–15. American Inst. of Nutrition, San Francisco, Calif. (R. W. Engel, Dept. of Biochemistry and Nutrition, Virginia Polytechnic Inst., Blacksburg.)

10–16. American Physiological Soc., San Francisco, Calif. (M. O. Lee, 2101 Constitution Ave., Washington 25.)

10–16. American Soc. for Experimental Biology, San Francisco, Calif. (C. C. Erickson, Inst. of Pathology, Univ. of Tennessee, 858 Madison Ave., Memphis.)

10–16. Federation of American Societies for Experimental Biology, San Francisco, Calif. (M. O. Lee, 2101 Constitution Ave., Washington 25, D.C.)

10–18. International Soc. of Urology, Athens, Greece. (Z. Kairis, 25 Voucourestiou St., Athens.)

11–14. Assoc. of American Geographers, annual, Memphis, Tenn. (B. W. Adkinson, Library of Congress, Washington 25, D.C.)

11–15. American Assoc. of Immunologists, annual, San Francisco, Calif. (F. S. Cheever, Graduate School of Public Health, Univ. of Pittsburgh, Pittsburgh 13.)

11–15. American Soc. of Biological Chemists, San Francisco, Calif. (P. Handler, Duke Univ. School of Medicine, Durham, N.C.)

12–15. Federation of American Societies for Experimental Biology, annual, San Francisco, Calif. (C. C. Pfeiffer, Dept. of Pharmacology, Emory Univ., Ga.)

12–15. International Union of Biological Sciences, 12th general assembly, Rome, Italy. (P. Weiss, 2101 Constitution Ave., Washington 25, D.C.)

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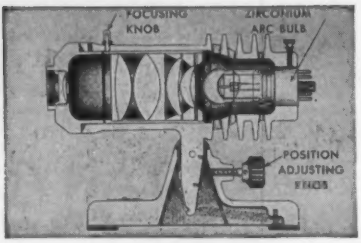

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Meetings & Conferences

April, contd.

15–15. Conf. on Biological Waste Treatment, New York, N.Y. (W. W. Eckenfelder, Civil Engineering Dept., Manhattan College, New York 71.)

14. World Meteorological Organization, 2nd cong., Geneva, Switzerland. (G. Swoboda, WMO, 1, Ave. de la Paix, Geneva.)

14–16. National Speleological Soc., Natural Bridge, Va. (E. Moffett, 3047 S. Columbus St., Arlington, Va.)

15–16. American Mathematical Soc., Brooklyn, N.Y. (AMS, 80 Waterman St., Providence 6, R.I.)

15–16. Eastern Psychological Assoc., Philadelphia, Pa. (G. Lane, Dept. of Psychology, Univ. of Delaware, Newark.)

15–16. Iowa Acad. of Science, Davenport. (J. L. Laffoon, Iowa State College, Ames.)

16. Committee for the Scientific Study of Religion, spring, New York, N.Y. (W. H. Clark, Hartford Seminary Foundation, Hartford 5, Conn.)

18–19. National Air Pollution Symposium, 3rd, Pasadena, Calif. (A. M. Zarem, 621 S. Hope St., Los Angeles 17, Calif.)

21–22. Eastern States Health Education Conf., New York Academy of Medicine, New York, N.Y. (NYAM, 2 E. 103 St., New York 29.)

21–23. Assoc. of Southeastern Biologists, annual, Charleston, S. C. (M. E. Gaulden, Biology Div., Oak Ridge National Laboratory, Oak Ridge, Tenn.)

21–23. Ohio Academy of Science, annual, Ohio Wesleyan Univ., Delaware. (R. W. Dexter, Kent State Univ., Kent, O.)

22–23. Arkansas Acad. of Science, annual, Searcy. (L. F. Bailey, Univ. of Arkansas, Fayetteville.)

22–23. Georgia Acad. of Science, Athens. (W. B. Redmond, Box 534, Emory University, Ga.)

24–26. American Association for the Advancement of Science, southwestern division, Sante Fe, N.M. (F. E. E. Germann, Dept. of Chemistry, Univ. of Colorado, Boulder.)

24–29. Inter-American Cong. of Radiology, Washington, D.C. (E. P. Pendergrass, 3400 Spruce St., Philadelphia 4, Pa.)

26–28. American Industrial Hygiene Assoc., Buffalo, N.Y. (H. F. Smyth, Jr., 4400 5 Ave., Pittsburgh 13, Pa.)

26–29. International Health Cong., Bournemouth, England. (P. A. Wells, 90 Buckingham Palace Rd., London, S.W.1.)

26–1. International Symposium on Arid Land Problems, Albuquerque, N.M. (J. A. Behnke, 1515 Massachusetts Ave., NW, Washington 5, D.C.)

27–29. Soc. for Experimental Stress Analysis, Los Angeles, Calif. (W. M. Murray, Central Square Station, P.O. Box 168, Cambridge 39, Mass.)

28–30. American Physical Soc., Washington, D.C. (K. K. Darrow, Columbia Univ., New York 27.)

28–30. Midwestern Psychological Assoc., Chicago, Ill. (L. J. Cronbach, 1007 S. Wright, Champaign, Ill.)

29–30. Alabama Acad. of Science, Tuscaloosa. (H. McCullough, Howard College, Birmingham, Ala.)

29–30. Colorado-Wyoming Acad. of Science, Greeley, Colo. (O. W. Olsen, Colorado A. & M. College, Fort Collins.)

Meetings & Conferences

April, *contd.*

29–30. Mississippi Acad. of Sciences, Meridian. (C. Q. Sheely, Box 574, State College, Miss.)

29–30. Seismological Soc. of America, Berkeley, Calif. (G. D. Louderback, Bacon Hall, Univ. of California, Berkeley 4.)

May

1–3. American Assoc. of Colleges of Pharmacy, Miami, Fla. (R. A. Deno, College of Pharmacy, Univ. of Michigan, Ann Arbor.)

1–3. American Soc. of Hospital Pharmacists, Miami Beach, Fla. (G. Neimeyer, 2215 Constitution Ave., NW, Washington, D.C.)

1–4. American Institute of Chemical Engineers, Houston, Texas. (S. L. Tyler, AICE, 120 E. 41 St., New York 17.)

2–4. American Geophysical Union, annual, Washington, D.C. (W. E. Smith, AGU, 1530 P St., NW, Washington 5.)

2–5. Electrochemical Soc., Cincinnati, Ohio. (H. B. Linford, 216 W. 102 St., New York 25.)

2–5. Research Equipment Exhibit and Symposium in Instrument Techniques and Applications, annual, National Institutes of Health, Bethesda, Md. (Supply Management Branch, NIH, Bethesda, 14.)

4–5. American Psychosomatic Soc., 12th annual, Atlantic City, N.J. (L. S. Kubie, APS, 551 Madison Ave., New York 22.)

4–6. American Inst. of Electrical Engineers (Middle Eastern District), Columbus, Ohio. (N. S. Hibshem, AIEE, 33 W. 39 St., New York 18.)

4–6. American Meteorological Soc., Washington, D.C. (K. C. Spengler, A.M.S., 3 Joy St., Boston 8, Mass.)

5–7. American Ethnological Soc., Bloomington, Ind. (Alice G. James, Hunter College, 695 Park Ave., New York 21.)

5–7. Kansas Acad. of Science, Lawrence. (C. T. Rogerson, Dept. of Botany, Kansas State College, Manhattan.)

5–7. Soc. for American Archaeology, Bloomington, Ind. (G. I. Quimby, Chicago Natural History Museum, Chicago 5, Ill.)

5–7. Soc. for Applied Anthropology, Bloomington, Ind. (E. Purcell, SAA, 61 W. 55 St., New York 19.)

6. American Assoc. of Spectrographers, 6th annual, Chicago, Ill. (F. E. Stedman, Engineering Research Laboratory, Bendix Aviation Corp., 401 N. Bendix Dr., South Bend 20, Ind.)

6–7. Illinois Acad. of Science, annual, Carbondale. (L. E. Bamber, 233 Natural History, Univ. of Illinois, Urbana.)

6–7. North Carolina Acad. of Science, annual, Davidson, N.C. (J. A. Yarbrough, Meredith College, Raleigh, N.C.)

6–7. North Dakota Acad. of Science, annual, Grand Forks, N.D. (J. Donald Henderson, University Station, Grand Forks.)

6–7. South Dakota Acad. of Science, Brookings. (A. L. Haines, Chemistry Dept., Univ. of South Dakota, Vermillion.)

6–8. American Psychoanalytic Assoc., Atlantic City, N.J. (R. L. Frank, 745 5 Ave., New York 22.)

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